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INVESTIGATIVE STUDY TO DETERMINE EFFECTS OF HYDRO-TREATED RENEWABLE JP-8 JET FUEL BLEND IN EXISTING FUELS INFRASTRUCTURE

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Contract No: FA8903-05-D-8737-SK-08

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AIR FORCE CIVIL ENGINEER SUPPORT AGENCY
OPERATIONS DIRECTORATE

■ **Tyndall Air Force Base, FL 32403-5323** ■ **United States Air Force**

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Investigative Study to Determine Effects of Hydro-Treated Renewable JP-8 Jet Fuel Blend in Existing Fuels Infrastructure

Pond Project 1110033 – AFCESA HRJ Fuel Study

- **Air Force Civil Engineer Support Agency (AFCESA)**
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Investigative Study to Determine Effects of Hydro-Treated Renewable JP-8 Jet Fuel Blend in Existing Fuels Infrastructure

Executive Summary

Hydro-Treated Renewable Jet (HRJ) Fuel also called Hydro-Treated Esters and Fatty Acids (HEFA) is a synthetic jet fuel being considered for use by the United States Air Force as well as other branches of the military and commercial aviation. The Air Force Petroleum Agency (AFPA) and Air Force Civil Engineer Support Agency (AFCESA) have been tasked with certification of the fuel for compatibility with existing fuels infrastructure. In support of that process, Pond & Company was contracted to study the possible effects of the new fuel blends on the existing fuels infrastructure. The study included the following tasks:

- Conduct a literature review to determine the state of industry knowledge and research on the effects of hydro-treated renewable HRJ/JP-8 blends or commercial equal fuel blends on Air Force fuels receipt, storage, and distribution systems and components.
- Evaluate and summarize existing studies, reports and investigations on effects of HRJ/JP-8 fuel blends (on material components and fuel system operations) making recommendations for any additional testing or investigations warranted to fully evaluate the potential effects of the new fuel.
- Perform a sustainment engineering evaluation on the performance of existing fuel filtration systems with additized HRJ/JP-8 fuel blends.
- Develop and provide recommendations for any infrastructure improvements for both material and operational aspects of implementation of HRJ/JP-8 fuel blends.

Conclusions and recommendations

- **Blends of up to 50% Hydro-treated Renewable JP-8 Jet Fuel (HRJ) or Hydro-treated Esters and Fatty Acids (HEFA) do not have a significant effect on US Air Force Fuels Infrastructure. It is recommended that the blended fuel be certified for use in USAF facilities.**

The introduction of the new fuel does have a few measureable effects that warrant monitoring:

- The fuel blends may reduce the life expectancy of certain Nitrile Rubber components in fuel systems where elasticity is a key property such as diaphragms in surge suppressors and control valves. The blends may also cause shrinkage in certain seals which may result in short term leakage when the new fuel is introduced into an existing system.
- Key components made of Nitrile, Neoprene or chlorosulfonated polyethylene synthetic rubber (i.e. Hypalon®) should be upgraded to Fluorocarbon rubber (i.e. Viton®), Urethane or other materials unaffected by the newer generation of synthetic fuels when they fail or are scheduled for replacement.

- Consideration should be given to upgrading standard design specifications to require Viton, Urethane or other materials compatible with synthetic fuels in place of Nitrile rubber to avoid potential conflicts with reduced life or other early failure of critical components. The incremental cost at the time of installation or new construction is negligible in the overall cost of a new fuel system.
- The introduction of HRJ or Synthetic Paraffinic Kerosene (SPK) blends to existing fuel systems will result in higher differential pressures measured across dirty filter media. This may result in earlier replacement of filter media than previously experienced. The immediate effect may be a spike in DP measured during a delivery of synthetic fuel blend when compared to the previous delivery of fuel. This reinforces the guidance that a replacement set of filtration elements be on hand to allow replacement without affecting operational capabilities.

Investigative Study to Determine Effects of Hydro-Treated Renewable JP-8 Jet Fuel Blend in Existing Fuels Infrastructure

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Investigative Study to Determine Effects of Hydro-Treated Renewable JP-8 Jet Fuel Blend in Existing Fuels Infrastructure

1.0 Background

Office of the Secretary of the Air Force (SECAF) has established a goal of 2016 for the United States Air Force (USAF) to be prepared to cost competitively acquire 50% of its domestic aviation fuel requirement via an alternative fuel blend with the alternative component derived from domestic sources producing fuel in a more environmentally-friendly manner than conventional petroleum production. Hydro-Treated Renewable Jet Fuel (HRJ) also called Hydro-Treated Esters and Fatty Acids (HEFA) is a synthetic jet fuel that is produced from bio-based feedstocks being evaluated within the aviation industry and by the USAF as a possible alternative fuel to satisfy this goal. The USAF Alternative Fuel Certification Office (AFCO) is charged with evaluation and certification of all new alternative fuel supplies with existing air frames and infrastructure.

Air Force Petroleum Agency (AFPA) and Air Force Civil Engineer Support Agency (AFCESA) have been tasked by AFCO to certify HRJ/JP-8 blended fuels for use in existing fuels infrastructure. A key step in this certification is to investigate the effects of HRJ/JP-8 blended fuels on fuel system components such as pumps, control valves and pressure flow sensors. The goal is that the new fuel be considered a “Drop-In” fuel, requiring no significant change in either infrastructure or operations to use the new fuel. As part of this process, AFCESA contracted with Pond & Company to perform a series of evaluations and tests to ensure compatibility with existing fuel infrastructure. The evaluation of these new fuels on existing airframes is being performed by others and was not a consideration in this study.

The foundation for evaluation of the effects of the new fuels is presently guided by the Military Handbook for Aerospace Fuels Certification (MIL-HDBK 510-1A) and by the American Society for Testing and Materials Standard Practice for Evaluating the Compatibility of Additives with Aviation-Turbine Fuels and Aircraft Fuel System Materials (ASTM 4054). The MIL-HDBK outlines the performance requirements for the fuels in addition to defining a series of evaluations focused on confirming compatibility with various materials and components.

2.0 Objectives

The primary objective of this study is to investigate the potential effects of HRJ blended jet fuel on the existing USAF fuels infrastructure to support a recommendation to certify or not certify the fuel. The recommendation is to be based upon evaluations, testing and documentation available within the aviation fuels industry as well as testing and evaluations performed within the scope of this contract and by the USAF.

In addition to making a recommendation related to certification, this study will make recommendations related to possible infrastructure and procedural improvements to improve safety and reliability with this and other potential synthetic fuels.

3.0 General Approach

The Statement of Work provided by AFCESA (FA8903-05-D-8737-SK08) provided the basis for the approach of this study. The basic tasks performed in this study include:

- Conduct a literature review to determine the state of industry knowledge and research on the effects of HRJ/JP-8 blends or commercial equal fuel blends on Air Force fuels receipt, storage, and distribution systems and components.
- Evaluate and summarize existing studies, reports and investigations on effects of HRJ/JP-8 fuel blends (on material components and fuel system operations) making recommendations for any additional testing or investigations warranted to fully evaluate the potential effects of the new fuel.
- Perform a sustainment engineering evaluation on the performance of existing fuel filtration systems with additized HRJ/JP-8 fuel blends.
- Develop and provide recommendations for any infrastructure improvements for both material and operational aspects of implementation of HRJ/JP-8 fuel blends.

3.1 Literature Review

The certification of a new aviation fuel in commercial industry within the United States is dictated by the American Society of Testing and Materials (ASTM) fuels committees. The process of evaluation of a new fuel or additive is an exhaustive process beginning with evaluation of the basic fuel properties as compared to the current standards for jet fuel. ASTM D1655 is the document that defines jet fuel within the US. It defines performance properties of the fuel, not the chemical make-up of the liquid.

ASTM developed a new standard D7566 to define the requirements for aviation turbine fuels made from synthesized hydrocarbons. The process for certification begins with the basic fit-for-purpose tests on the liquid fuel. These tests are typically laboratory tests on the ability of the fuel to burn and handle similar to Jet Fuel. The next step is to perform component or rig testing to ensure the fuel can be used in existing engine components followed by full scale engine tests. Finally the fuel is flight tested. During this process a report is generated that documents the performance characteristics of the fuel and any specific requirements or restrictions placed on the fuel in order to have it perform within the limits of petroleum jet fuel. The data is accumulated and published as an ASTM Research Report which is then referenced by aircraft and engine manufacturers and government agencies in the final certification and acceptance of the fuel.

While materials compatibility is part of this process, much of the focus is on the aircraft propulsion systems, not ground infrastructure. The majority of the data collected does not address the possible effects on the ability to store the fuel and safely dispense it into

an aircraft. The process does however provide a significant amount of data on the chemical properties of the new fuel and parallels can be drawn to project the impact of the new fuels on infrastructure components.

The first fuel to achieve certification through the commercial process is made through a Fischer-Tropsch (F-T) process called Synthetic Paraffinic Kerosene (SPK). The primary feedstock in the process is natural gas or coal, however the process can also be used to convert gas produced from biomass feedstocks into liquid fuel. Annex 1 of ASTM D7566 defined the performance properties of the SPK as a blendstock to be mixed up to 50% with petroleum jet fuel to produce an acceptable jet fuel. The final blended product would meet all of the requirements of ASTM D1655 as Jet Fuel.

The F-T process produces synthetic hydrocarbon kerosene that has virtually none of the impurities found in typical petroleum fuels. It also produces a pure paraffinic hydrocarbon liquid with no aromatics. These compositional differences present both benefits and concerns in adopting this product for use in aviation as a possible fuel. The lack of certain impurities (like sulfur) affects the density and lubricity of the fuel. The lack of aromatic hydrocarbons affects the compatibility of the fuel with certain elastomers in the fuel system. Extensive testing was performed on various blends of SPK fuel during the certification process both within the commercial aviation industry and by the military.

Up to a 50% blend of SPK has been certified in the commercial markets and at least one supplier has developed a full scale production facility. Data on the handling and performance of the fuel is still being collected and shared within the industry. There are several pilot projects to utilize the F-T process to make SPK from biomass feedstocks. To date only small batches of this fuel have been produced, but the final product meets the requirements of the ASTM D7566 Annex 1 blendstock.

The HRJ process begins with a biomass feedstock either plant or animal based, and through a series of steps, produces a pure paraffinic hydrocarbon very similar to SPK. The treatment process produces a series of hydrocarbon chains that has no “fingerprint” of the original feedstock and is consistent and uniform (at least in the small scale production systems in place). Within the commercial community, HRJ is called HEFA and has been certified in blend ratios up to 50% under ASTM D7566 Annex 2.

The ASTM Research Reports and other documentation published draw many direct parallels between the SPK and HRJ fuels. The chemical make-up of both families of fuel are similar in the lack of impurities and aromatic hydrocarbons. The resulting fuel must be blended with petroleum jet fuel to consider the fuel a “drop-in”. The key concerns highlighted in the various reports are low density, low or no electrical conductivity, low lubricity and no inherent antioxidant properties.

The low lubricity, conductivity and lack of antioxidants are addressed through the use of additives into either the blendstock or the final jet fuel product. The only additive that is typically added as part of the refining process is the antioxidants. Because of the chemical properties of the fuel, degradation of the fuel will result in formation of

peroxides. Most suppliers inject small amounts of antioxidants to stabilize the fuel in the processing phase which prevents this from occurring in the typical handling and storage lifespan of jet fuel. For comparison, petroleum jet fuels as they age produce gums in the fuel due to chemical reactions with the other impurities in the fuel.

The lack of aromatic hydrocarbons is one of the primary contributors to the lower density. Overall the differences in the paraffin ratios and hydrocarbon distribution have very little impact on the properties and characteristics of the final blended fuels that are approved for commercial use[1]. The lack of aromatics does however have an effect on material compatibility and performance of key components in fuel infrastructure.

Logistics – Neat or Blended Fuel

As we consider the effect of the new synthetic fuels on the USAF fuels infrastructure, one key assumption is clear: the USAF will only handle, store and dispense blended fuels. The supply chain process that is in place to supply fuels to the various branches of the military relies upon the Defense Logistics Agency (DLA-Energy) to purchase and deliver fuel to the various bases and fuel storage facilities around the world. The anticipated supply process will dictate that the blending of the synthetic fuel and petroleum based fuel be performed prior to delivery.

The blending process is critical in ensuring the final product meets the requirements of both ASTM D7566 and ASTM D1655. ASTM D7566 defines a procedure where each of the blend components is tested to verify that it meets minimum requirements prior to blending. For instance the HRJ blendstock must meet the minimum requirements defined in Annex 2 of that standard. The petroleum component must meet ASTM D1655, but with additional limitations. When blended, the final product must meet the minimum characteristics of D7566 final, which includes minimum aromatic content and density requirements that the synthetic fuel cannot meet alone. In short, these characteristics of the petroleum component must be high enough to bring up the overall average of the final product to the minimum levels and/or the blend ratio must be adjusted to compensate for the makeup of the petroleum blendstock.

Detail Specification: Turbine Fuel, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37), MIL-DTL-83133, was revised (rev. H) in October 2011 to include the same requirements on synthetic blends in the definition for JP-8 fuel.

This certification requirement allows this report to evaluate the effects of a final blended fuel (of up to 50% synthetic) that meets the final product requirements in ASTM D7566 and MIL-DTL-83133H. The aromatics and density of the final product will be within the defined range for standard petroleum based jet fuel. The investigation did yield information on handling neat synthetic fuel. This information was used as a predictive tool to consider possible long term effects only.

1 USAF Report on Comparative Evaluation of SemiSynthetic Jet Fuels

3.2 Materials and Component Compatibility

The literature study yielded a large mass of data from testing performed during the original evaluation process with SPK fuels. The Air Force Research Laboratory also provided results of testing with HRJ following the MIL-HDBK 510 testing protocols. Most of the HRJ data presented data in parallel with SPK data which confirmed the position that the two fuels are similar. Data was available with many materials for both neat and blended fuels.

Defining “Compatible”

When considering the question of materials compatibility and the possible effect on components, Pond reviewed the standard protocols and material lists defined for testing in the various codes and standards related to fuel storage and dispensing systems, not just those established for evaluating synthetic fuels. The basis for defining compatible varies greatly depending upon the standard referenced. Examples of the different procedural requirements are as follows:

- MIL HDBK 510, Appendix D, Nitrile O-Ring Seals describes a typical 28 day immersion at 160^{o}F evaluating for change in tensile properties, hardness, compressions set and volume swell.
- MIL T-52983G - Collapsible Fuel Tanks describes both a 14 day immersion in fuel at 160^{o}F followed by 14 and 42 days immersed in distilled water evaluating for changes in tensile properties and volume swell.
- API/IP STC 1529 - Aviation Fueling Hose calls for testing change in elongation and fuel soluble matter at exposures of 42 and 96 hours at 104^{o}F.
- UL 971 - Non-metallic Piping for Flammable & Combustible Liquids – assembled 18” lengths of pipe are filled with product and maintained at 100^{o}F for 30, 60, 90 and 180 days minimum. Burst pressure, pull test and crush tests are performed on the pipe samples after each period.

Given the range of definitions for “compatible”, one could simply rely upon MIL HDBK 510. A task under this contract was to review the handbook and make recommendations for modifications or update so additional considerations were taken. The article “Definitive Guide to Accelerated Testing”[2] provided additional guidance for evaluating the long term effect of the new fuels. This document provides guidance to consider the failure mechanisms in selecting test procedures. It also recommends consideration of performance beyond the initial date of delivery, or “How will an aged material respond to the new fuel?” and “What maintenance actions can counteract the effect of failure?” These concepts were considered when evaluating each class of materials, where it is used and what test data is available to determine the possible effect of the new fuel.

One example of how these concepts impact the evaluation is the compatibility of Nitrile or Buna-N Rubber. The prior testing for compatibility on this product was for O-Ring seals. In that mode, shrinkage in the material will result in a leak in a mechanical joint.

[2] AMMTIAC Tech Solutions Article 15, “Definitive Guide to Accelerated Testing”

This failure mode is important when considering this material in air frames and engines. In ground infrastructure, Nitrile rubber also exists as diaphragms in control valves and bladders in surge suppressors where the failure mechanism is dramatically different. Flexibility and elongation properties are equally important in defining a material as “compatible” in these applications.

Previous studies have been completed to define the various materials that exist in fuel infrastructure. The most recent of these studies was completed by NAVFAC Engineering Service Center Navy Alternative Fuels Material Assessment (Report CR-10-045-E&U)[3]. This report lists virtually every material used within the Navy fuels programs. The sections that pertain to fixed fueling systems on land (Table C-2) parallel the fuels infrastructure for Air Force and Army installations as well.

Each class of materials was evaluated for its general compatibility with paraffinic hydrocarbon liquids. Where data was available in published reports or industry publications, it was noted. By considering groups or classes of materials, the ones with possible effects were singled out and additional effort was made to make sure data was available to document the anticipated effect on the expected failure mechanism. A gap analysis report was presented to AFCESA/AFPA with recommendations for additional testing to be performed. Narrative of the material compatibility analysis is included as Appendix D of this report.

The additional testing focused on Nitrile and Fluorocarbon (i.e. Viton®) rubber materials and Cork/Nitrile gasket materials. In addition to the typical MIL HDBK 510 tests, the samples were evaluated for solubility. The test term was also extended to include multiple data points for trend analysis to allow for projected long term effects as opposed to a snapshot. The results of the additional testing are presented in AFRL Evaluation Report (SA104002).

Material Compatibility Findings

Most materials react to the neat and blended synthetic fuels the same as they do with petroleum based jet fuels. In general metals are unaffected because of the low conductivity of the fuels.

Certain elastomeric materials are affected by the HRJ fuel and fuel blends. The neat HRJ has a much greater effect than a blended fuel due to the lack of aromatic hydrocarbons. In the case of elastomeric seals, the aromatic hydrocarbons cause the materials to swell which improves the sealing ability. When exposed to HRJ and SPK fuels, these materials will shrink which may cause mechanical joints to leak.

Nitrile rubber is the most widely used elastomeric material affected by the new fuels. It is used widely in fueling systems including as seals, control valve diaphragms and surge suppressor bladders. The anticipated life expectancy of nitrile rubber materials will be

[3] NAVAC ESC REPORT CR-10-045-E&U, Impact of Alternative Aviation and Marine Distillates Fuels on USN and USMC Infrastructure – Final Submittal

reduced when used in systems containing HRJ or SPK fuel blends. The effect would be much greater in systems handling neat HRJ. Given the typical failure modes of the various components, routine maintenance and repair programs can compensate for the effect over the life of the systems.

Neoprene and Chlorosulfinated Polyethylene synthetic rubber (Hypalon®) are two other elastomers that have been used in fuel system components. These materials are no longer recommended as "new" materials, however they may still exist in older systems as hoses or seals in floating roofs. These materials will be significantly affected by the new fuels. Because they should be replaced with newer standard materials after failure with or without the introduction of new fuels, the long term effect is negligible.

As a comprehensive reference, Table C-3[4] from the NAVFAC report has been reproduced and expanded as Appendix D of this report to include the anticipated effects of HRJ and HRJ blended fuels on the various materials and components.

3.3 Operational Effects

Operational effects of the new fuel were also considered in investigating the impact of the new fuel. As stated previously both HRJ and SPK have lower lubricity, density and conductivity. These characteristics can each impact the operability of key components within the fuels infrastructure or impart a reason for procedural changes to ensure safety in fuel handling.

Low lubricity can impact the operation of pumps and metering systems that have moving components that rely upon the fuel to provide any measure of lubrication. In commercial jet fuels there is no specification for lubricity. JP-8 however does have a defined limit. Lubricity in jet fuel is measured using a ball on cylinder lubricity evaluator or BOCLE test (ASTM D5001). JP-8 requires a maximum wear scar diameter of 0.65mm. There is a natural concern about the lubricity of synthetic jet fuels since, due to their purity, they do not contain the organic acids or other polar compounds that provide lubricity in conventional fuel. For military applications this concern is moot since JP-8 and JP5 both include a lubricity additive. Test results on blended fuels indicate the standard injection of additive into a blended fuel will pass the specified limits.

Low conductivity can be a safety related issue. However, like lubricity, the JP-8 specification includes a conductivity additive that overcomes the lack of conductivity in synthetic fuels. In the initial phase of filtration tests, the conductivity did decrease more than expected prior to the commencement of each test. During the second phase of testing, the phenomenon could not be recreated. The literature review included some studies that indicated the enhancement provided by the additives did not last as long with HRJ and SPK as with standard petroleum fuels.

[4] NAVAC ESC REPORT CR-10-045-E&U, Impact of Alternative Aviation and Marine Distillates Fuels on USN and USMC Infrastructure – Final Submittal

Density is the other area where synthetic kerosenes do not meet the ASTM D1655 standard for jet fuel. This is attributed to the lack of aromatics for the most part. When considering fit-for-service, density is not a critical characteristic. From a pure operational aspect density only is a factor when considering metering and gauging of the fuel. The accuracy of tank gauging and metering systems required by DLA-Energy, is based upon a defined range of density. While the equipment is capable of accurately measuring liquids with densities at or below the range of neat HRJ, certain equipment may have to be calibrated or programmed to operate with the wider operational range. An analysis of density and the thermal expansion properties of HRJ determined that storage and handling of up to a 50% blend will not require any modification to the programming or calibration of metering and gauging systems.

With the introduction of the synthetic fuel blends, density has become a more important measurement. A quick API Specific Gravity measurement will confirm the blend meets JP-8 specification requirements. Because the synthetic blendstock will always have a density below the normal range of jet fuel, it must be blended with petroleum fuels with a density in the medium to high range to bring the average density into the appropriate range and maximize the blend ratio of synthetic blendstock. Measuring the density of the delivered fuel will confirm the blend is correct as a quick quality assurance test.

Aside from the "as delivered" characteristics, two additional areas of study have been completed that affect fuels infrastructure: long term stability and potential biological contamination.

Synthetic kerosenes are different from petroleum fuels in how they age. During the production of the fuel, antioxidants are added to the fuel to stabilize the fuel, preventing formation of peroxides in the fuel mixture. Petroleum based fuels typically form gums when aged. The standard fuel tests define gum content as one of the quality assurance tests. There is no test for peroxides in the standard QA protocol. This area has not been heavily studied or reported within the industry as it relates to synthetic fuel blends. It is the intent that antioxidants used in the processing are adequate in controlling aging (similar to those used in hydro-treating petroleum feedstocks). The reports that did pertain to long term stability of the fuel did not identify any concerns with regard to fuel degradation.

The second factor in long term stability that has been studied was degradation of conductivity over time relative to the type of storage system. The initial study[5] was performed with SPK fuels, but due to the chemical similarities between the two fuels, the results with HRJ would be similar. There will be a larger decrease in conductivity over time with the synthetic blended fuels versus petroleum only JP-8. The study did not recommend any special action with regard to storage in steel tanks, however did raise a question related to storage in collapsible fuel tanks/bladders.

[5] Change in Electrical Conductivity of Synthetic Fuel in Filtration and Storage Simulations Final Report, SwRI® Project No. 08-14406.02

Finally, research was performed to evaluate if the introduction of synthetic fuels increases the likelihood of biological growth or bio-fouling in jet fuel. A presentation[6] of the data was found in the literature study that included both HRJ and SPK fuels. The research showed that there was no significant difference in microbial growth tendency between the alternative fuels tested here and Jet A-1. The study continues to say that the synthetic fuels inhibit biofilm growth.

3.4 Filtration System Evaluation

In addition to the consideration of the effect of HRJ on general components of the system, the effect on filtration systems was considered a crucial evaluation. One key task therefore was to perform an evaluation on the impact of the new fuel on existing filtration equipment with regard to the ability to effectively remove water and solids from the fuel. To perform this evaluation various tests were performed following the API/EI 1581 5[h] Edition "Specifications and Qualification Procedures for Aviation Jet Fuel Filter Separators" with a variety of fuels and filters.

In the first phase of testing three groups of tests were performed, each to evaluate different potential effects of the new fuel:

- Soak Test: This series of tests is focused on evaluating basic material compatibility by immersing the assembled filters in fuel for 28 days, after which evaluating the elements for degradation in construction.
- Water Coalescing Effectiveness: This series of tests compared the water coalescing effectiveness of new clean filter elements to that of elements from the Soak Test phase. The intent is to determine if there was any significant change in the performance of the coalescer after immersion.
- Overall Filter/Coalescer Performance: This series of tests was the most rigorous, following the API/EI 1581 single element protocol to determine if the fuel blend altered the solids/water removal performance of several filter/coalescer elements.

The general conclusions from the first round of testing are as follows:

- There were no notable concerns from the "Soak Test" testing. Exposure had limited effect on the various elements during the immersion period.
- There was no significant affect on the results with the addition of +100 additives or the use of filters rated for +100 fuels.
- There was no measurable change in coalescing performance between new and aged elements as defined in this study. The application of this conclusion is limited in that "aged" did not include exposure other than immersion.
- Within the standard operational range of differential pressures as defined by the filter manufacturers and UFC 3-460-03 (typically 15 psi to 20 psi), all variations of fuels and filters did effectively remove water and solids from the fuel stream.

[6] Microbial Growth and Biofilm Formation: Jet A-1 vs. Six Alternative Fuels; University of Dayton Research Institute, AFRL/RZPF, University of Dayton; May 2010

However, the introduction of HRJ into the fuel blend did result in higher differential pressures compared to straight petroleum JP-8 during the testing.

- Failure to monitor differential pressures (DP) during operations can result in filter element failure and water contamination of fuel downstream of filtration. This is more of a concern where 5th edition elements have been installed in systems certified under the 3rd edition of the standard where the flow through the elements may be higher.

In order to provide a more definitive evaluation of the impact of the additives on the fuel a second phase of filtration tests were performed. In general the tests followed the API /EI 1581 5 h Edition single element protocol, with petroleum JP-8 and a 50/50 blend of HRJ and petroleum JP-8 with the additives being varied as outlined below.

1) No additives
2) Static Dissipater Additive (SDA)
3) Fuel System Icing Inhibitor (FSII)
4) Corrosion Inhibitor/Lubricity Improver (CI/LI)
5) SDA – FSII
6) SDA – CI/LI
7) FSII – CI/LI
8) SDA – CI/LI – FSII
9) Same fuel as test 8 except run 50/50 mix A1 and A3 silica (no red iron oxide as solids challenge and of only run 0.5% water in final challenge)

A tenth test was performed using the fully additized fuel (same as test 8) except at the same higher flow rates as the Phase I testing. The results from this test matched the results of the Phase I test which validates combining the two data sets for consideration.

The conclusions from the second phase of testing are as follows:

- The ability of the 5th edition M filter elements to remove water and solids from the fuel was not significantly affected by the addition of HRJ to the fuel blend with any combination of additives.
- The addition of HRJ to the blend of fuel does result in an increase in differential pressures at key stages of the testing for both neat and fully additized fuels. The change due to the addition of HRJ was roughly the same in both tests, about 3 psid.
- The single element tests with the individual additives (tests 2-4) resulted in differential pressure test curves that are virtually the same with or without HRJ included in the fuel blend.
- Additive combinations (tests 5-8) resulted in varying effects on the DP during the tests. Only the combination of SDA and FSII increased the effect of adding HRJ to the blend (DP closer to 4 psid)
- The removal of the red iron oxide from the solids challenge resulted in an increased DP during the second water challenge which was the opposite of the

expected results. The effect of adding HRJ to the fuel blend was largest in this test (almost 8 psid at the end of the second water challenge).

Flow rate through the filters is an important factor when performing these tests. Typically, in order to qualify under the 5th edition M requirements the flow rates are lower (per inch of effective length) than a 3rd edition element. The first phase of testing was performed at roughly 34 gallons per minute which is on the high end of the typical 3rd edition performance range. The second phase of testing was run at roughly 26 gallons per minute which is slightly lower than the maximum for a typical 5th edition M element. Establishing the correct flow varies with the type of element being used and the manufacturer. Additional testing was performed to correlate the values from the two test phases and allow consideration of the higher flow rates.

An additional conclusion was derived from the additional tests:

- Operating 5th edition M elements above the manufacturer's defined range will result in higher differential pressures during all phases of the test. This can become a factor when 5th edition elements are installed in 3rd edition vessels.

The complete report from the filtration study is included as Appendix E of this report.

4.0 Conclusions

Blends of up to 50% Hydro-treated Renewable JP-8 Jet Fuel (HRJ) or Hydro-treated Esters and Fatty Acids (HEFA) do not have a significant effect on US Air Force Fuels Infrastructure. It is recommended that the blended fuel be certified for use in USAF fuel infrastructure.

The introduction of the synthetic fuel blends does have a few measureable effects that warrant monitoring:

- The fuel blends may reduce the life expectancy of certain Nitrile Rubber components in fuel systems where elasticity is a key property such as diaphragms in surge suppressors and control valves. The blends may also cause shrinkage in certain seals which may result in short term leakage when the new fuel is introduced into an existing system.

- Key components made of Nitrile, Neoprene or chlorosulfonated polyethylene synthetic rubber (i.e. Hypalon®) should be upgraded to Fluorocarbon rubber (i.e. Viton®), Urethane or other materials unaffected by the newer generation of synthetic fuels when they fail or are scheduled for replacement.

- Consideration should be given to upgrading standard design specifications to require Viton®, Urethane or other materials compatible with synthetic fuels in place of Nitrile rubber to avoid potential conflicts with reduced life or other early

failure of critical components. The incremental cost at the time of installation or new construction is negligible in the overall cost of a new fuel system.

- The introduction of HRJ or SPK blends to existing fuel systems will result in higher differential pressures measured across dirty filter media. This may result in earlier replacement of filter media than previously experienced. The immediate effect may be a spike in DP measured during a delivery of synthetic fuel blend when compared to the previous delivery of fuel. This reinforces the guidance that a replacement set of filtration elements be on hand to allow replacement without affecting operation capabilities.

- Review the standard process for upgrading filtration elements in older vessels to ensure the rated flow is not exceeded for the new elements as this can result in reduced performance of the filtration system as opposed to the anticipated improvement.

As a task under this contract Pond has also provided recommendations related to updating MIL HDBK-510 to include some of the longer term testing and additional materials discussed in this report. By including the additional evaluations, it will allow for more predictive analysis of future fuels and additives being considered for use in USAF fuels infrastructure. The recommendations related to MIL-HDBK 510 are not included in this report, but were submitted separately.

Appendix A

Acronyms/Abbreviations

AFCESA	Air Force Civil Engineer Support Agency
AFCO	Alternative Fuel Certification Office
AFPA	Air Force Petroleum Agency
API	American Petroleum Institute
ASTM	ASTM International (formerly American Society for Testing and Materials)
BOCLE	Ball On Cylinder Lubricity Evaluator (ASTM D5001 Test Procedure)
CI/LI	Corrosion Inhibitor/Lubricity Improver
DLA	Defense Logistics Agency
DoD	Department of Defense
DP	Differential Pressure
EI	Energy Institute
F-T	Fischer-Tropsch Process
FSII	Fuel System Icing Inhibitor
HEFA	Hydro-Treated Esters and Fatty Acids
HRJ	Hydro-Treated Renewable Jet
JP-8	Jet Propellant 8
MIL-HDBK	Military Handbook
psid	pounds per square inch differential
RIO	Red Iron Oxide
SDA	Static Dissipater Additive
SECAF	Office of the Secretary of the Air Force
SPK	Synthetic Petroleum Kerosene
UFC	Unified Facilities Criteria
USAF	United States Air Force

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Appendix B
Bibliography of Literature Search

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01 – ASTM Standards

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Appendix C
Material Compatibility Gap Analysis

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HRJ Fuel Blend Study

Contents

1. Executive Summary

An Integrated Project Team (IPT) was comprised in 2006 to standardize the protocol for certifying new fuels. Through this initiative, a Short List of metallic and non-metallic materials were flagged as potential risk products and compiled as test representatives for certification in MIL-HDBK-510-2(USAF). The Short List materials identified in MIL-HDBK-510 include samples of the predominate seal, diaphragm, and hose materials used in fuel storage and transfer infrastructure.

Compatibility of Short List materials with alternative jet fuels can be predicted by comparing the chemical composition of the material and the chemical composition of the proposed alternative jet fuel, in this case JP-8/HRJ blended fuel. Actual test results, when available, can then be compared with expected results to develop strong relationships between the chemical composition of the alternative jet fuel and the chemical composition of the tested material.

This report investigates the chemical composition of Short List materials found in fuel storage and transfer infrastructure of typical aviation turbine fuel systems. From the chemical composition of the Short List materials predictions are made regarding the expected interaction of these materials in JP-8/HRJ blended fuel. When test data was available, the actual test data was compared to the expected results. When material test data in JP-8/HRJ blended fuel was not available, material compatibility of the Short List material in other chemical species, determined in this report to be similar to JP-8/HRJ blended fuel, was used to fill the gaps.

In most cases test results of materials investigated in this report followed closely with the results that would be expected after exposure to JP-8/HRJ blended fuel, and are considered to be acceptable for use in JP-8/HRJ blended fuel with no impact on performance or service life. The one exception noted was nitrile used for O-rings and hoses. These components may experience premature aging due to loss of plasticizers and reduced volume swell when used in JP-8/HRJ blended fuel.

2. Introduction

Materials used to construct aviation storage, transport, and distribution systems have been studied and recorded by Pond & Company and others (1) (2). This report evaluates the materials identified through these studies for compatibility with neat HRJ and JP-8/HRJ blended fuel. A section of this report is dedicated to each class of material. In each section the chemical composition of each class of fuel system materials is briefly examined, and the expected chemical resistance of each class of material to the effects of JP-8, neat HRJ, and JP-8/HRJ blended fuel is reviewed. The findings are products of detailed literature reviews and research. Unfortunately, limited neat HRJ and JP-8/HRJ blended fuel material compatibility test data is available. When test data was available for a specific class of materials the test results have been compared to the expected results. When test data was not available compatibility of the

materials in other chemical species, determined in this report to be similar to JP-8/HRJ blended fuel, was used to fill the gaps.

3. HRJ Description

Hydrotreated Renewable Jet Fuel (HRJ) is a synthetic paraffinic kerosene fuel that is produced from bio-based feedstocks. The feedstocks have been refined to four preferable sources: camelina, jatropha, algae, and tallow.

The term HRJ and Bio-SPK (Synthetic Paraffinic Kerosene) are often used interchangeably. HRJ is a specific type of Bio-SPK due to its unique hydroprocessing. Hydroprocessing is a chemical process that reacts a feedstock material with hydrogen at high temperatures and pressure in the presence of a catalyst. The process results in medium length (nine to sixteen carbon atoms) straight chain carbon molecules that are fully saturated with hydrogen atoms.

"Chemically, there is nothing new in FT and HRJ jet fuels, except the absence of aromatics, minimal cycloparaffins, and the absence of impurities (3). The absence of impurities such as sulfur, coupled with a reduction in the maximum size of carbon molecules input into the combustion process, results in cleaner emissions. A closer look at the chemical break down of HRJ compared to JP-8 reveals that HRJ is made up predominately of medium sized paraffins and a small quantity of cycloparaffins, while JP-8 contains alkylbenzenes, indans, tetralins, and naphalenes. The components that make up HRJ are nearly 100% paraffinic while the components that make up JP-8 are only around 80% paraffinic.

HRJ's molecular make up of shorter, less complicated paraffins that break down more easily results in a higher specific energy when compared to conventional JP-8. The higher specific energy translates to better overall fuel efficiency for HRJ.

The lubricity level of neat HRJ is less than that of JP-8. However, it has been shown that when SD/LI additive is added to HRJ at the levels required for JP-8 the lubricity increases to an acceptable range.

The largest factors promoting the development and use of HRJ are the initiatives to produce a cleaner fuel and the goal to reduce the dependency of the USA on foreign oil. The first initiative is supported by multiple studies, corroborating that emissions are reduced by up to 80% by use of HRJ over conventional JP-8 (4). The second goal is still yet to be seen. HRJ can be produced in small quantities but the key to cutting dependency lies within the capability to successfully increase production capacity and to reduce production costs to levels competitive with crude oil production. A study conducted by RAND/MIT predicts that the production capacity can reach as high has 60,000 barrels per day with the current production capacity and the completion of near term planned HRJ production facility projects (5).

4. HRJ Raw Material Descriptions

4.1 Camelina

Camelina is a flowering plant related to the mustard or cabbage family. It is native to Northern Europe and Central Asia, but it has also been introduced into the US. It has been chosen as a feedstock because it's seed produces an abundance of oil. Camelina also requires very little water and nitrogen to flourish and requires limited upkeep and weed control making it appealing to farmers because it requires low overhead costs.

Camelina has had historical importance as far back as the Roman Empire due to it's seed's properties. Romans grew camelina for its use in oil lamps, a process still used today. Montana is currently expanding its farmland to meet increasing demand for camelina oil due to it's use in biodiesel production.

While its full potential is unknown, research trials conducted by the University of Minnesota over the past 30 years has yielded cultivation information that can be used to expedite future progress. Their studies showed better production rates in northern locations of Minnesota, with seed yields of up to 1,700 kg/ha (6).

The Royal Dutch Airline used camelina oil in a 50/50 blend with standard jet fuel to record the first commercial passenger flight using biofuels, and studies have shown that biofuel developed from camelina feedstock creates 80% less emissions when compared to standard jet fuels (4).

4.2 Jatropha

Jatropha Curcas has emerged as one of the leading feedstock candidates for HRJ due to its high production of oil. The seed is comprised of up to 40% refinable oil (7). However; questions circulating around Jatropha remain unanswered. It is grown abundantly in its natural habitats, but it has not been properly domesticated. Thus the effect of Jatropha on the environment and soil quality outside of it's native habitat remain unknown.

Jatropha is a shrub/tree like plant native to Central and South America. It is resistant to drought and pests making it easy to cultivate. The highly toxic compounds that make the plant resistant to pests also affect humans. The toxin found in the foliage and seeds effects the body much like snake venom and the sap irritates the skin.

Jatropha is known to be toxic, but it can still be grown with other cash crops such as foods and does not compete for water or nutrients with other crops. In addition, Time Magazine recently cited that Jatropha has the potential to produce over 1,600 gallons of fuel per acre per year, while capturing four tons of Carbon Dioxide per acre (8). Jatropha oil is also very competitive with crude oil. In 2008, a barrel of crude oil cost $122 and a barrel of Jatropha oil cost about a third less at $43.

Air New Zealand conducted a test flight using 50/50 blends of Jatropha biofuel and Jet-A1 at the end of 2008, and they announced plans to increase usage of the new fuel to over 10% of the airline's total fuel consumption (7).

4.3 Algae

Algae's quest to become a legitimate feedstock for a biofuel began during the oil crisis of the 1970's during the Carter administration. The price of gas dropped back to $1.00 per gallon after the crisis in the 90's and the push for an algae biofuel dwindled. The recent rise in the price of crude has reignited research and testing of algae as a biofuel feedstock.

Algae require an abundance of carbon dioxide, light, and a warm water source to thrive. In the water rich state of Alabama, three billion gallons of fuel can potentially be produced while using only 3% of its total land mass (9).

The lack of land use is a strong benefit of algae as a feedstock. With an increasing concern placed on the appropriation of land for food crops and other uses, the fact that algae would not compete with food sources makes it an appealing option.

Carbon dioxide consumption is a substantial down side of algae. Economically practical growth rates require greater than 20 grams of carbon dioxide per square meter per day. The atmosphere contains between 300 and 350 ppm of CO^2, roughly 1% of what the algae would need, which is much too low to sustain the required economic growth rate (9). However, the use of open or closed ponds with carbonation pits and algae grown in translucent tubes known as photo bioreactors have proven themselves as viable options for cultivating and harvesting algae.

Currently there are over two dozen separate projects and corporations involved in making algae a feasible biofuel source. The National Renewable Energy Laboratory has estimated that algae can produce up to 10,000 gallons of biofuel per acre per year. The report "Algae 2020" speculates that the price of biodiesel produced from algae could be as low as $1.00 per gallon.

4.4 Tallow

Tallow is fat, oil, or grease taken from animals and plants. This feedstock is generated mainly from an animal source. This is a favorable feedstock source because it would not directly compete with food sources and tallow has an abundance of carbon.

Some potential drawbacks of using tallow as a feedstock materializes in production and processing. The process for converting tallow is complex due to complications in separating esters. Tallow contains free-fatty-acids that make the production of high ester counts with a

single-stage process ineffective. Thus esterfication for tallow is forced to work on a two-stage process using a base-catalyst and an acid-catalyst, respectively. This multi-stage system cuts into production efficiency (10).

To completely evaluate the potential of tallow as a feedstock, the entire process of harvesting this feedstock must be assessed. Increasing the demand for tallow feedstock will increase the demand for animal fat such as beef and swine. The energy required to produce this increase in animal feed and turn the tallow into jet fuel coupled with the increase in corn feed prices do to the manufacture of ethanol, cuts largely into the efficiency of mass production of tallow produced HRJ. Especially considering that it takes six kilograms of feed to produce one kilogram of weight in cattle.

5. HRJ Production Process (Hydrotreating of triglycerides)

Current aviation fuels generally come from a crude oil based feedstock that contains a mixture of various hydrocarbons that do not break down easily when directly applied to certain operational uses. These various hydrocarbons are classified as paraffinic, naphthenic, or aromatic depending on their predominant composition.

The most important step in the conventional oil refining process is to distill the crude oil to the desired fuel range. Like any distillation process, the quality of yielded product is affected by the temperature at which the process is kept. Kerosene is the distillate that is most commonly used as the fraction for contemporary jet fuels like JP-8 and Jet A-1, and it is distilled at around 400°F (11). Almost all fuel forms are based off of crude oil and depending of various distillation techniques, the product can have quite different characteristics. But, before the feedstock is ready to be distilled, certain tidying of the raw liquid must be administered.

Feedstocks for HRJ contain contains triglycerides and impurities such as oxygen, sulfur, and nitrogen. Triglycerides are an ester formed from glycerol and three fatty acids. To reduce the triglycerides to single chain hydrocarbons and remove feedstock impurities a process called hydrotreating is employed. Hydrotreating is a type of hydrogenation process that removes +/- 90% of these imperfections in HRJ feedstock.

Hydrotreating is not a single process but a system of processes. The feed stock is deaerated followed by adding hydrogen. The hydrogen acts as a reactant while heated to 600-800°F and pressurized in a catalytic reactor. The reactor charges the fluid and activates the nitrogen and sulfur to bond with the excess hydrogen creating ammonia NH_3 and hydrogen sulfide (H_2S). The triglycerides are also reacted and broken down in the process to form long chain saturated hydrocarbons, CO2, and water. The waste NH3, H2S, CO2, and water is easily collected and removed from the mixture. Once hydrotreating is complete the resultant hydrocarbon paraffin mixture is distilled and processed no differently than Jet A-1 or JP-8 (12). Hydrotreating is most

effective when placed before the distillation so that the impurities do not hinder the subsequent subprocesses (13).

6. Makeup of HRJ versus Material Precursor

The feedstocks for the HRJ process are composed of fatty acid derivatives – both fatty acids or fatty acid esters. These molecules have an oxygen functional group at one end and a long aliphatic straight chain hydrocarbon with variable amounts and locations of double bonds on the other. The majority of these fatty acids are attached to a glycerol backbone and are known as acylglycerols. Most of these are triacylglycerols or triglycerides, where three fatty acid chains are attached to the glycerol backbone through ester groups. Since all the double bonds, estergroups, and carboxylic acid groups are removed in the hydrotreating process, all fatty acid derivatives lead to the same products: n-paraffins (3).

The product is paraffinic kerosene composed of mostly branched paraffins in the kerosene boiling point range. The composition of paraffins in HRJ are indistinguishable from the composition of paraffins in FT or petroleum derived jet fuel (3).

7. Material Compatibility Evaluation for Alternative Jet Fuels

A “Short List” of fuel system materials was compiled as a result of the JP-8+100 material survey. The Short List materials were found in the construction of fuel tanks, fuel handling systems, and engines. The metallic and non-metallic materials found on this list are meant to serve as the worst case products or respective materials from each type of system. In 2006, an Integrated Project Team, or IPT, was assembled and tasked to standardize the protocol for certifying new alternative fuels. The IPT developed a revised “Short List” of metallic and non-metallic materials. The revised Short List materials were flagged as potential risk materials. The IPT developed MIL-HDBK-510-2 which was to be used for certification of alternative fuels.

The IPT broke the procedure for certifying new fuels in MIL-HDBK-510-2 into three stages called subsets. Subset 1 is laboratory testing of a specific or combination of representative materials. They are soaked in a baseline fuel as well as a candidate fuel at elevated temperatures and compared after soaking. This first step is a general evaluation while identifying any possible compatibility issues. Subset 2 is a complete evaluation and investigation of the materials that fail Subset 1. Upon completion and acceptable results from Subset 2 testing, Subset 3 progresses to large scale testing and/or flight tests.

8. Compatibility of Metals

The compatibility of metals with candidate fuels is evaluated on the basis of three criteria: corrosion, light-optical evaluation, and microstructural evaluation (14).

No direct resistance testing of HRJ or JP-8/HRJ blended fuel in metals has been conducted. As a result, compatibility evaluations for metals require assumptions and comparisons to be made with fluids of similar chemical properties. HRJ is comprised of multiple straight chain paraffins varying from n-C_6 to n-C_{19} and typically within C_7 to C_{13} range (15). Material compatibility of HRJ can be approximated by comparison to material compatibility of common straight chain saturated hydrocarbons such as heptane (C_7) and hexane (C_6).

Heptane and hexane have been extensively studied. Manufacturing compatibility charts show that both heptane and hexane have little to no action with steel, 316 stainless steel, aluminum, or cast iron (16). They performed with the highest rating for brass, nickel, aluminum bronze, cast iron, 304 & 316 stainless steel (17). Both fluids also rated at “Excellent” for compatibility for all metals including Alloy 400/405 in corrosion charts produced by Swagelok (18).

HRJ/JP-8 blended fuels have chemical properties that are similar to JP-8/FT. According to studies conducted by Robert and Company on JP-8/FT blends, no material compatibility issues arose in lab testing of metallic piping or metallic components of fueling infrastructure, (1) and “all evaluated Fisher Tropsch fuels performed equivalent to or exceeded the control JP-8 samples” (19).

Sheppard AFB conducted operational tests on a current Type III hydrant fueling system with JP-8/FT blended fuel. No fuel handling-related issues were demonstrated on metallic components during and after the tests.

The use of HRJ/JP-8 blended fuel and neat HRJ should have no effect on the metal components used to construct fuel systems and performance of HRJ/JP-8 blended fuel and neat HRJ in these components should be similar to the performance of these materials in standard JP-8.

9. Compatibility of Coatings

Epoxies consist of two components that react with each other forming a hard, inert material. Part A consists of an epoxy resin and Part B is the epoxy curing agent, sometimes called hardener (20). Typical fuel system coating use polyamides as curing agents.

Epoxy resin begins with the reaction of two compounds, bisphenol A and epichlorohydrin. Bisphenol A is the chemical product of combining one acetone unit with two phenol groups. Structurally phenol contains a benzene ring with an attached hydroxyl (20).

The reaction between bisphenol A and epichlorohydrin removes unreacted phenol and acetone and attaches two glycidyl groups to the ends of the bisphenol A, creating the standard epoxy resin. The size of the resulting molecule (and hence its molecular weight) depends upon the ratio of epichlorohydrin to bisphenol A (20).

Polyamides are formed by the reaction of aliphatic polyamines and dimer acids of either tall oil fatty acids or from soya or castor oil. The use of polyamides as a hardener is common and produces coatings with good low temperature curing, good color, and good chemical resistance. They generally produce coatings with excellent adhesion, water resistance & flexibility (21).

Cured epoxy polyamides contain some hydroxyl and aromatic groups in the final structure. The hydroxyl and aromatic groups are expected to slightly interact with the aromatics in standard JP-8 fuel and JP-8/HRJ blended fuel.

Accelerated soak test data of epoxy polyamide in JP-8 and JP-8/HRJ blended fuel is available. The coating had a slight reduction in pencil hardness after exposure to JP-8/HRJ blended fuel when compared to test results after exposure to standard JP-8, and tape adhesion tests after exposure to each type of fuel produced the same results for both types of fuel (22).

Accelerated soak testing of epoxy polyamide coatings produced similar results for JP-8/HRJ blended fuel and neat HRJ, and the performance of the coating in applications with both types of fuel would be expected to be similar to the performance of these coatings in standard JP-8 service.

10. Compatibility of Polymers

10.1 Material Classifications

Thermoplastics, often referred to as simply plastics, belong to the polymer material family along with thermosets and elastomers. They can be found in multiple applications from manufacturing toys and phones to bearings and gears. This versatility is due to their extensive properties. “Thermo-” signifies the reaction dependence on temperature and “-plastic” originates from Greek meaning capable of being shaped and molded. Together, thermoplastics can be shaped and molded by way of heat changes.

Thermoplastics are characterized and defined by their unique molecular structure. They are generally found in a structure known as a linear polymer. This occurs when double bonded monomer units are broken and single bonds are reformed in unison.

This formation of long chains often leaves an unorganized chain structure. The chains weave among one another but never reform bonds with themselves or with other chains maintaining a simple molecular structure. This is similar to a bowl of spaghetti and how the noodles are arranged around one another.

The bonds linking the carbon molecules together are physical (weak van der Waal's forces) rather than chemical. Heat acts to weaken the bonds (23). This temperature-sensitive attribute allows the material to be broken down, stretched, and remolded to new formations. Longer chains with more carbon atoms give thermoplastics more strength, flexibility, and toughness due to the increased bonding forces. It can be related to candle wax. Candle wax has a predefined shape until it is heated past its melting point where it changes into liquid. In this state it can be reformed into various molds and when cooled it returns to a solid in the shape of the mold.

Thermosets are the opposite of thermoplastics. The process for thermoplastics is reversible and the material is recyclable where as thermosets cannot be reformed. Thermosets are formed by chemical bonding or cross-linking between molecules to create a permanent, three dimensional network (23). The chemical reactions create stronger bonds than the physical bonds between the molecules of the thermoplastics.

Thermoplastics molecules have long linear chains and resemble spaghetti while, thermosets have a more complex chain structure called cross-linking. Cross-linking occurs when individual molecules are ionically or covalently bonded in a 3-dimensional shape with other molecules. This complex orientation of molecules makes the material less malleable (23). The polymer is permanently molded when the melting point is increased beyond the curing temperature. The molding process generally takes longer than for thermoplastics due to the time dependent curing process. After curing and cooling, thermosets cannot be reformed. Thermosets will decompose at a temperature lower than the melting point of the thermoset.

Thermosets and thermoplastics are used throughout industry from applications like lubricants to components like diaphragms. Their ability to withstand high and low temperatures makes them essential in fueling. Thermoplastics are moldable which allows them to fill voids and imperfections between two surfaces. This makes them a great option for sealants and gaskets (24). They resist chemicals and water making them effective coatings to provide strength and corrosion resistance. Thermosets are more resistant to creep with increased strength but increased strength is accompanied by increased brittleness at cold temperatures when compared to thermoplastics.

10.2 Thermoplastics

10.2.1 Polyamides (Nylon)

Polyamides are commonly known as nylon. Nylon was the first synthetic polymer that was commercially profitable in the production of toothbrushes and stockings. Although it is silky in nature, nylon is a thermoplastic and is recyclable, thus melting before it reaches the burning point. Nylons get their name from the way amide bonds are used to link monomers of specific sub-groupings. The sub groups used to develop the nylon is describe by the number of carbons contained within the monomer and is added as a suffix to the name of the nylon. For example,

Nylon 6 contains 6 carbons per monomer. The addition of more carbon atoms in the monomer strengthens the link (25).

Nylon is used in a wide range of commercial and military applications from parachutes to hydraulic hoses. Its numerous variations allow for manipulation of its properties to best suit an individual need like tensile strength, ductility and ascetics. For example, nylon's characteristics can be adjusted to produce a shiny/silky finish or a dull/semi-abrasive material.

Nylon is extremely resistant to the elements including insects, fungi, mold, mildew, rot, and various chemicals. Nylon is often used as a protective outer shell on fuel hoses due to it's ability to withstand outdoors environment for extended periods of time (25).

The only testing available for nylon was completed on Nylon 101 film. This product was tested in pure JP-8, JP-8/FT blend, JP-8/HRJ blend, neat FT, and neat HRJ.   Test samples of the film were subjected to tensile strength and elongation tests after a 28-day soak period in the fuels. Tensile strength testing showed an increased tensile strength after soaking in each type of fuel. The increase in tensile strength showed a slight dependence on aromatic content with the lowest tensile strength increase recorded for the JP-8 sample of 1393 psi, and the highest increase in tensile strength recorded for the neat HRJ of 2550 psi. The average tensile strength increase for the five fuels was 2024 psi (22).

Elongation tests showed a dramatic decrease in elongation from the control sample. Elongation testing on the control sample yielded a result of 360%, while elongation testing on the fuel soaked samples yielded an average of 65%. The reduction in elongation was independent of fuel aromatic content (22).

Studies were conducted by NAVFAC on alternative fuels, USN, and USMC on infrastructure. They indicate that nylon has been used in aircraft fuel system hoses, dielectric bushings, ball valve seats, plug valve steam seals, control valve diaphragms, liquid pump body seals, sensor components, and reinforcing fabric for dike liners, tank liners, and collapsible tanks (2).

The effects of neat HRJ and JP-8/HRJ blends on nylon are similar to the results documented for standard JP-8 fuel, and the performance of nylon in HRJ and JP-8/HRJ blended fuel are expected to be similar to the performance of nylon in standard JP-8 service.

10.2.2 Polyoxymethylene (POM or Delrin)

Polyoxymethylene is a polymer thermoplastic also known as a polyformaldehyde, polyacetal, or simply Acetal. Dupont has marketed this type of material under the trade name Delrin. The polymer family includes homopolymer and copolymer variations. The copolymer forms improve polymer thermal stability.

Acetal is confined to particular uses because it is known to deteriorate when exposed to UV sunlight for extended periods. It is also susceptible to acid hydrolysis and oxidation making it

particularly sensitive to attack by halogens such as chlorine. Low levels of chlorine found in potable water supplies can be enough to cause stress corrosion cracking in Acetal components. These conditions can cause failure in Acetal O-rings and seals.

Acetal has a very high stiffness and strength to weight ratio, it exhibits minimal surface friction, and it is semi-hydrophobic in nature. These properties make acetal attractive for use in fueling systems. Acetal's minimal surface friction and semi-hydrophobic nature reduces the amount of static charge developed by fluid flow across the material.

Studies have shown that Acetal has been used for O-rings and seals in fueling nozzles, sensors, plugs used in strainers, discharge control valve disks, components in air release/vacuum breaker valves, and sight flow indictor components (1) (2).

No resistance test data of Acetal is available for JP-8/HRJ blended fuel and neat HRJ. However published data for the chemical compatibility of Acetal with jet fuels is excellent. Acetal's compatibility is also rated as excellent for use with straight chain saturated hydrocarbons like hexane and heptanes (26).

The effects of neat HRJ and JP-8/HRJ blended fuel on Acetal are expected to be similar to the results documented for standard jet fuels and keronsene, and the performance of Acetal in HRJ and JP-8/HRJ blended fuel is expected to be similar to the performance of Acetal in standard JP-8 service.

10.2.3 Polyvinyl Chloride (PVC)

Polyvinyl Chloride (PVC) is a vinyl polymer constructed of repeating vinyl chloride monomer groups. PVC contains 57% chlorine by mass. It can be made softer and more flexible by the addition of plasticizers. The most widely used plasticizer is phthalates. This form of PVC is used to make flexible hoses and tubing (27). PVC shows high mechanical and tensile strength and can be used in applications ranging in temperatures from -15°C to 60°C (28).

"Before PVC can be made into finished products, it requires conversion into a compound by the incorporation of additives such as heat stabilizers, UV stabilizers, lubricants, plasticizers, processing aids, impact modifiers, thermal modifiers, fillers, flame retardants, biocides, blowing agents, and optionally pigments" (27).

PVC is resistant to fuels and fuels that contain hydrocarbons (5). However, the listed resistance is based on the base polymer only. Many of the additives used in PVC, including plasticizers, are soluble in hydrocarbon fuels. The solubility of the plasticizers will result in PVC becoming brittle in applications with prolonged exposures to hydrocarbon fuels.

Studies have shown that PVC has been used in storage tank floating roof pan seals, hoses, liquid level sensor floats, dike and tank liner coatings, and pressure vacuum vent screens (1) (2).

No resistance test data of PVC is available for JP-8/HRJ blended fuel and neat HRJ. PVC applications in fuel systems such as dike liners are typically not wetted, and the performance of PVC with JP-8/HRJ blends and neat HRJ for limited exposure is expected to be similar to that of standard JP-8 fuel.

10.2.4 Polytetrafluorethylene (PTFE or Teflon)

Polytetrafluoroethylene (PTFE) is a synthetic fluoropolymer of tetrafluoroethyene. PTFE is commonly known by the DuPont trademarked name Teflon. PTFE is a fluorocarbon solid, high molecular-weight compound, consisting wholly of carbon and fluorine atoms. It is a white solid at room temperature. PTFE's properties result from the aggregated effect of the carbon-fluorine bonds (29).

Fluorine atoms contain a high electronegativity, a property that is lost when fluorine bonds with carbon. The bond between fluorine and carbon displays a property known as a London dispersion force, which is a type of van der Waal's forces. The fluorine carbon bond generates an instantaneous polarization known as a multipole. Multipoles, due to the inconsistency of electron density, cannot interact with stable molecules and can only interact with nearby multipoles. This internal interaction gives PTFE strength, it's ability to repel water and oil, it's self cleaning ability, and prevents oxidation and corrosion. PTFE's chain structures do not cross link. This property allows PTFE to be molded, but also makes PTFE susceptible to creep (30).

Studies have shown that PTFE has been used in valve stem seals, body seals, seats, O-rings, sight flow indicators, vacuum pressure vent pallet diaphragms/seals, emergency vent seals, ball joint seals, floating roof pan mechanical shoes/wiper blades, pump mechanical seals, and many others (1) (2).

PTFE resistance test data is available for JP-8, neat FT, and JP-8/FT blended fuel. PTFE resistance test data for films used for wire insulation in neat HRJ and JP-8/HRJ blended fuel is also available. Test of PTFE in JP-8, neat FT, and JP-8/FT blends have shown that PTFE is compatible with all fuel types, and that compatibility is independent of aromatic content. The test results of PTFE film varied between the types of fuels, but no correlation between aromatic content of the fuel type and the test results was observed. The test measurements varied widely between the initial film tests completed for FT fuels and later tests performed with HRJ fuels; however, all tests yielded acceptable test results (22).

The effects of neat HRJ and JP-8/HRJ blended fuel on Teflon are expected to be similar to the results documented for standard JP-8, and the performance of Teflon in HRJ and JP-8/HRJ blended fuel is expected to be similar to the performance of Teflon in standard JP-8 service.

10.3 Thermoset-Elastomers

10.3.1 Epichlorhydrin (ECO or Hydrin)

Epichlorhydrin (ECO) commonly referred to as Hydrin is a polymer (31). It comes in three different formations: as a homopolymer, as a copolymer of epichlorohydrin and ethylene oxide, or as a terpolymer of epichlorohydrin, ethylene oxide, and a cure site monomer. Each formation has slightly different properties but similar general characteristics.

Compared to other elastomers, epichlorhydrin has a very high resistance to oils and other hydrocarbons. It holds up very well to ozone and common wear due to the environmental conditions. Epichlorhydrin has a wide temperature range remaining stable in conditions varying from -55°F to +275°F, and it has less sub-zero stiffness than its nitrile and chloroprene (neoprene) counterparts (31).

Studies have shown that ECO has been used in seats and seals of double block and bleed valves and ground fueling hoses (1) (2).

ECO test data is available for standard JP-8, JP-8/ FT fuel blends, JP-8/HRJ fuel blends, neat FT, and neat HRJ. The test samples showed a decrease of volume swell versus aromatic content of the fuel. Standard JP-8, with an aromatic content of 19%, caused a volume swell of 2.7%. JP-8/FT blended fuel and JP-8/HRJ blended fuel, with aromatic contents of 9.5%, caused volume swell of 2.4% and 1.7%. Neat FT and HRJ, with an aromatic content of 0%, caused a volume swell of -2.1% and -2.2% respectively (22).

Tensile strength results showed no correlation to aromatic content and all results were above the acceptable test limits with the exception of the neat FT sample. This sample was tested at 117 psi below the 1500 psi limit of MIL-DTL-26521 Specification (22).

Hardness and elongation testing results showed no correlation to aromatic content and all results were within the acceptable test limits for all fuels tested (22).

Volume swell of ECO in JP-8/HRJ blended fuel was very similar to volume swell of neat JP-8, and performance of ECO in JP-8/HRJ blends would be expected to be similar to that of standard JP-8. A decrease in volume swell was observed for ECO in neat HRJ. The volume swell was minimal, but could result in fuel system leaks if a system that was exposed to JP-8 was switched to neat HRJ.

10.3.2 Polychloroprene (CR or Neoprene)

Polychloroprene (CR) commonly referred to as Neoprene is a family of synthetic rubbers that are produced by polymerization of chloroprene (32). For dry rubber applications, neoprene is

available in three different families: G, W, and T types with variations in each family (33). All types of Neoprene resist degradation from sun, ozone, and weather, perform well in contact with oils, remain useful over a wide temperature range, and display outstanding physical toughness (34). Neoprene is an inert chemical making it well suited for industrial applications such as gaskets, hoses, and corrosion-resistant coatings (32).

Neoprene's resistance to aromatic hydrocarbon fuels (JP-8) is listed as "poor to fair" and its resistance to aliphatic hydrocarbons (saturated hydrocarbons) is listed as "poor to good" (35). Alternate resistance charts list neoprene as "not recommended" for jet fuel and "good" for heptane and hexane. For general compatibility charts, neoprene would have an unacceptable resistance to HRJ/JP-8 blended fuel and limited application ability in neat HRJ.

Studies have shown that Neoprene has been used in floating roof pan wiper seals, outer shells of shell-and bladder tanks, O-rings in globe valves, solid pipe gaskets, and sight flow indicator seals (1) (2).

No testing data of neoprene in JP-8/HRJ blended fuel and neat HRJ is available. Compatibility charts show that neoprene should not be used in applications where it comes into direct contact with aromatic hydrocarbon fuel (i.e. JP-8) and should only be used sparingly in applications where it comes into direct contact with aliphatic hydrocarbon fuel (i.e. HRJ or FT). The performance of seals, gaskets, and O-rings would be expected to be unacceptable in applications where it comes in contact with JP-8/HRJ blended fuel.

10.3.3 Fluorocarbon

Fluorocarbon Rubber (FKM) also called Viton comes in different grades with varying physical properties. "Despite FKM's higher cost compared to other elastomers, they are often the first choice in demanding seal environments (36). Fluorocarbon rubber has excellent resistance to high temperature, ozone, oxygen, mineral oil, synthetic hydraulic fluids, aromatics and many organic solvents and chemicals. Low temperature resistance is normally not favorable and for static applications is limited to approximately -15 °F. Under dynamic conditions, the lowest service temperature is between 5°F and 0 °F (37). "The reliability of FKMs is unrivaled in fuels, lubricants, and special fluids used in aerospace" (36).

Standard types of Viton fluorocarbon products are classified as A, B, or F according to their relative resistance to attack by fluids and chemicals (38). A fourth class of Viton, called Viton Extreme includes specialty fluorocarbon polymers that exhibit properties not typical of the A, B, or F Viton classes. Fluorocarbons are divided into categories based on several factors which include monomer composition and cure mechanism. From these classes, generalizations can be drawn on the mechanical/physical properties, fluid/heat resistance, and processing characteristics (36).

The Viton A class includes two general polymers types. "First there are the copolymers made from two monomers of vinylidene fluoride (VF_2) and hexafluoropropene (HFP)" (36). This

copolymer has been commercialized as Viton A (39). “These polymers are most often cured with bisphenol AF and a phosphonium salt. Copolymers are typically 65-66% fluorine by weight” (36). A specialty Viton designated as GLT can also be placed in the Viton A class. This copolymer is made from monomers of (VF_2) and fluorinated vinyl either. GLT uses a peroxide curing system. This polymer provides the same excellent resistance to heat and fluids that is typical of the A types and exhibits significantly improved low temperature flex characteristics compared to standard A types (38).

The Viton B class includes two general polymer types. Viton B polymers are composed of VF_2, HFP, and a third monomer of tetrafluoroethylene (TFE) (36). “TFE is added to increase the fluorine content of the polymer” (36). Viton B shows better long-term resistance to heat, swelling in oils and solvents, and chemical degradation from certain oil additives (39). The additional fluorine content can result in reduced compression set and low temperature sealing properties. Terpolymers are most often cured with bisphenol AF and range in fluorine content from 67-70% by weight (36). A specialty Viton designated GBLT can also be placed in the Viton B class. This terpolymer replaces the HFP with fluorinated vinyl ether. GBLT uses a peroxide curing system. This polymer exhibits similar resistance to heat and fluids and exhibits improved low temperature flex characteristics compared to the standard B types (39) (40).

The Viton F class includes two general polymer types. Viton F is composed of VF_2, HFP, and TFE monomers. Viton F fluorocarbons offer the best fluid resistance of all Viton types (41). Viton F is cured with bisphenol AF and has a fluorine content of 70% (38). A specialty Viton designated GFLT can also be placed in the Viton F class. This terpolymer replaces the HFP with fluorinated vinyl ether. GFLT uses a peroxide curing system. This polymer exhibits similar resistance to heat and fluids that is typical of the F types and exhibits improved low temperature flex characteristics compared to the standard F types (38) (40).

The Viton Extreme class includes a specialty Viton designated as ETP. ETP is a colpolymer of TFE and perfluoromethyvinyl ether. This unique combination of monomers provides outstanding resistance to fluids. Viton ETP exhibits the same excellent resistance to acids and hydrocarbons typical of A, B, and F types. Unlike conventional fluoroelatomers, Viton ETP provides excellent resistance to low molecular weight esters, ketones, and aldehyds (42).

Viton type fluorocarbons exhibit outstanding resistance to attack from mineral acids and aliphatic and aromatic hydrocarbons. The high fluorine content of the polymer results in less volume increase by penetration of the fluid into the fluorocarbon (38). Volume swell testing completed by DuPont on the standard types of Viton in fuel showed a volume increase of 4% for the A types, 3 % for the B types, and 2% for the F types (38). Testing completed by Dayton University on two, class A Vitons (general use A type Viton meeting AMS 7276 requirements and low temperature A class GLT Viton meeting AMS-R-83485 requirements) showed a linear dependency on the volume swell of the A types due to aromatic content of the fuel tested. Volume swell in fuel containing 19% aromatics was measured at 6.7%, volume swell in fuel containing 9.5% aromatics was measure at 5.5%, and volume swell in fuel containing 0% aromatics was measured at around 4.5% (22). The Class B and Class F Vitons would be

expected to perform as good if not better than the Class A type Vitons in the fuels due to the increased fluorine content of these classes over the A class Vitons.

Additional accelerated soak tests of Viton diaphragm material commonly used in control valves was conducted by the AFRL (Air Force Research Laboratory). At the end of a 56 day period the volume swell from JP-8 exposure was recorded at 5.1%, the volume swell from JP-8/HRJ blended fuel was recorded at 4.1%, and the volume swell from neat HRJ was recorded at 3.3%. These results correlated well with previous soak tests performed on Viton O-ring material.

Studies show that Viton is used extensively in fuel systems. These studies document that Viton is used in pressure vacuum vent seals, transfer hoses, pipe swivel joint face/O-ring seals, hose coupling seals (i.e. breakaways and dry breaks), all types of valve seats, body seals, stem seals/rings, pump mechanical seals/gaskets, fuel monitor O-rings, hydrant valve seals, check valve disks, pressure relief valve O-ring seals, pipe gaskets, surge arrestor O-ring seals/bladders, air eliminator O-rings, and instrument components.

Accelerated 28 day soak test results showed that Viton A exhibits acceptable performance results in JP-8/HRJ fuel blends and neat HRJ (22). The Class B and F Vitons would be expected to perform better than Class A Vitons due to the higher fluorine content.

10.3.4 Perfluoroelastomer (FFKM or Kalrez)

Perfluoroelastomer (FFKM) is commonly referred to Kalrez. Kalrez is used in highly aggressive chemical processing, semiconductor wafer processing, pharmaceutical, oil/gas recovery, aerospace, and petroleum applications (43). Kalrez parts are available in a number of different compounds that are formulated to optimize properties to give the best possible performance in various applications. Modification of the finished properties is achieved by use of fillers and other additives (44). Kalrez 4079 is a low compression set product for general-purpose use in O-rings, diaphragms, seals, and other parts used in the process of aircraft industries. It is a carbon black-filled product with excellent chemical resistance, good mechanical properties, and outstanding hot air aging properties (44).

Studies have shown that Kalrez has been used in hose couplings (breakaways and dry breaks) and globe valve O-ring seals.

No testing of Kalrez in HRJ/JP-8 blended fuel and neat HRJ is available. Dupont lists the chemical resistance of Kalrez as “excellent” to exposure to aromatic and aliphatic oils (45) (46). From this information, Kalrez would be expected to perform well in HRJ/JP-8 blended fuel and neat HRJ.

10.3.5 Polyurethane (PU)

Polyurethane (PU) is any polymer consisting of a chain of organic units joined by urethane links. Polyurethane polymers are formed through step-growth polymerization by reacting a monomer containing at least two isocyanate functional groups (diisocynate) with another monomer containing at least two hydroxyl groups (diol) in the presence of a catalyst (47). Materials with tailor-made properties can be produced from the broad variety of chemicals (48).

The two main building blocks of polyurethanes are known as soft blocks and hard blocks. The soft blocks form an elastomer matrix which gives polyurethane elastic properties. The hard blocks act as multifunctional tie points that function both as physical crosslinks and reinforcing fillers (48).

The soft blocks are made up of long flexible polyether or polyester chains with an average molecular weight of 600 to 4000. The hard blocks are made up by a combination of ridged aliphatic or aromatic diiscocynates and short chain diols called chain extenders. The bulky diisocynates react with the short chain diols with an average molecular weight of 61 to 400 to make large hard block molecules (48) (49).

Polyurethanes with soft blocks made of polyesters are classified as polyester urethanes and Polyurethanes with soft bocks made of polyether are classified as polyether urethanes. The esters that make up polyester urethane are more polar than ethers but less polar than alcohols (50). The two groups can be further classified by the type of hard blocks used to make up the polymer. The two most common hard block classifications are aliphatic and aromatic (49).

Polyether urethanes have superior low temperature properties, are inherently stable when exposed to high humidity, and are more fungus resistant. Polyester urethanes have greater abrasion resistance and tensile strength than polyether. Polyester is more resistant to fuels and offers better aging resistance. However, polyester urethanes will eventually break down when exposed to conditions of high humidity (49).

Nonpolar solvents such as hexane, heptanes, and paraffin oil have almost no effect on the polar polyurethanes. Slight swelling is observed at high temperatures. Aromatic liquids like toluene cause a very severe swelling of PU. The degree of swelling is dependent on the structure of the polyurethane. Ester types swell less than ether types and hard polyurethanes swell less than soft ones (48).

Studies have shown that PU has been used in collapsible tank liners, tank floating roof pan seals/wipers, underwing nozzle O-ring seals, dike liner coatings, and tank liner coatings (1).

Polyester type polyurethanes are used in fuel applications due to their superior resistance to fuels. The degree of swell of polyester urethane is expected to increase as the aromatic content of the fuel increases. Available data from soak testing of polyurethane does not correlate well with expected results. The swell in standard JP-8, with an aromatic content of 19%, was measured as 23.2%. The swell of JP-8/FT blended fuel, with an aromatic content of 9.5%, was measured as 23.2%, and the swell of neat FT, with an aromatic content of 0%, was measured at 3.5%. In a later soak test, the swell in JP-8/HRJ blended fuel with an aromatic content of 9.5%

was measured at 27.5%, and the swell in neat HRJ with an aromatic content of 0% was measured at 19.7% (22).

Volume swell of PU in JP-8/HRJ blended fuel was very similar to volume swell of neat JP-8, and performance of PU in JP-8/HRJ blends would be expected to be similar to that of neat JP-8. A decrease in volume swell was observed for PU in neat HRJ. The volume swell was much smaller, and would most likely result in fuel system leaks if a JP-8 system that utilized polyester urethane O-rings and seals was switched to neat HRJ.

10.3.6 Urethane

Urethanes are the building blocks of polyurethane but urethanes and polyurethanes are very different. Polyurethane is made from polyethers, polyesters, glycols and di-isocyanates while urethanes has a very distinct grouping of $C_3H_7NO_2$ making them carbmic acid ethers and amides. These differences make urethanes harder and more brittle materials with a good resistance to oxidation and a more stable relationship with hydrocarbon solvents.

Urethanes are normally chosen for applications due to their inexpensive cost, excellent abrasion/wear resistance, and shock load capacity. Urethanes can be manufactured to perform from -90°F to 200°F. They offer great electrical properties and high load-bearing capacity (51).

Uses of urethane in fuel systems which bring it in direct contact with fuel are limited. Studies indicate that urethane has only been used in floating roof pan seals (1).

No testing of urethane in JP-8/HRJ blended fuel or neat HRJ is available. Compatibility charts list the compatibility of urethane with standard jet fuel as fair to good, and compatibility charts list compatibility of urethane with hexane and heptanes as good (52). The performance of urethane in contact with JP-8/HRJ blended fuel and neat HRJ is expected to be similar to urethane's performance in standard JP-8.

10.3.7 Nitrile Butadiene (NBR or Buna-N)

Nitrile Butadiene Rubber (NBR), also called Buna-N or simply nitrile, will have physical properties that vary depending on the copolymer ratio used in manufacturing.

"NBR is actually a complex family of unsaturated copolymers of acrylonitraile and butadiene" (53). "NBR is the work horse oil-resistant elastomer of choice for typical sealing applications" (54). "Most NBR manufactures make a least 20 conventional elastomer variations. Acrylonitrile and butadiene ratios are varied for specific oil and fuel resistance and low temperature requirements" (53). "Some NBR elastomers are hydrogenated to reduce the chemical reactivity of the polymer backbone, significantly improving heat resistance" (53). Hydrogenated NBRs are typically classified as HNBR.

The copolymer of butadiene and acrylonitrile that make up the basic NBR structure is produced by emulsion polymerization (54). NBR materials are polar due to the acrylonitrile content (55). “Acrylonitrile is a very polar molecule due to the lack of symmetry of the triple bonded nitrogen coupled with the nitrogen’s lone-pair electron effect. The lone pair effect plus a large dipole moment created by the nitrogen develops a very strong H-bonding potential” (54).

“The acrylonitrile content is one of two primary criteria defining each specific NBR grade” (53). Various grades of NBR can contain 18 to 50% acrylonitrile (55). “The acrylonitrile level, by reason of polarity, determines several basic properties, such as oil and solvent resistance, low-temperature flexibility/glass transition temperature, and abrasion resistance” (53). Increases in acrylonitrile increases or improves resistance to fuel/oils, abrasion resistance/hardness, tensile strength/modulus, processing behavior, gas impermeability, heat resistance, and compatibility with polar plastics. An increase in acrylonitrile will decrease or reduce resilience, elasticity and low temperature flexibility (55). “In view of these opposing realities, a compromise is often drawn, and a medium acrylonitrile content is selected” (37). Grades based on percent composition of acrylonitirle and typical uses are as follows:

- 16%, 20%, & 23% for Very Low Temperature Service
- 26% for Improved Abrasion
- 27% & 29% for Low Temperature Service
- 33% for General Purpose Use
- 39% for Fuel, Oil, and High Temperature
- 40% for Fuel, Oil, Freon, and High Temperature
- 45% for Fuel, Freon, and High Temperature (55)

Compounding of nitrile to make it suitable for specific applications will have an impact on how the material responds to exposure to fuels with varying aromatic content. In general, nitrile materials requirements should be expected to perform in a consistent way due to the specification requirements.

Most compatibility charts list compatibility of NBR with fuels that contain aromatics as “Fair” (56). The polar nature of NBR materials allows them to interact with the aromatic content of fuels. The most evident symptom of this interaction is volume swelling. The symptom of NBR volume swell has limited the use of NBR to static seal type applications in fuel systems that contain aromatics.

Studies, involving current infrastructure, have shown that nitrile has been used extensively in aviation fuel systems. Nitrile has been used in inner shells of shell and bladder tanks, floating roof pan seals, split ring coupling seals, hose seals, swivel O-ring seals, dry break/breakaway seals, all types of valve seats/seal, pump mechanical seals/gaskets, fuel filter/fuel monitor seals, hydrant valve seals, check valve disks/seals, relief valve seats/seals, pipe gaskets, surge arrestor bellow seals, expansion joint packing, air eliminator seals, and relaxation tank seals (1) (2).

Accelerated soak testing on several nitrile grades including nitrile bladder inner liner, nitrile O-rings, and nitrile hose material has been conducted in standard JP-8, JP-8/FT blended fuel, JP-

8/HRJ blended fuel, neat FT, and neat HRJ (22). The nitrile bladder inner liner was not required to meet any standard material specification. The nitrile hose material was required to meet MIL-H-4495 specifications, and the nitrile O-rings were required to meet AMS-P-5315 specifications.

The nitrile inner liner test data does not correlate well with expected results. Recorded volume swell results were not proportional to the aromatic content of the fuel. Standard JP-8 with an aromatic content of 19% produced a volume swell of -4.7%. JP-8/HRJ blended fuel and JP-8/FT blended fuel with an aromatic content of 9.5% produced volume swells of 6% and –4.7% respectively. Neat HRJ and neat FT with an aromatic content of 0% produced volume swells of -8.7% and -12.1% respectively (22). The negative volume swells data recorded indicates that the fuels are interacting with other components included in the inner liner material. Large amounts of filler and other materials may be included in the nitrile inner liner material to give it the characteristics required for a bladder. These additional components appear to be soluble to a small extent in the aliphatic content of the fuel. This effect seems to be somewhat masked by the higher aromatic content fuels which tend to interact with the polar molecules of nitrile and slightly swell the material.

The nitrile hose material test data correlated better with expected results. Standard JP-8 produced a volume swell of 2.3%. JP-8/HRJ blended fuel and JP-8/FT blended fuel produced volume swells of -6% and -4.9% respectively, and neat HRJ and neat FT produced volume swells of –10.5% and -9.6% respectively (22). The negative volume swell data recorded indicates that the fuels are interacting with other components included in the nitrile compound. The effect seems to be masked by the higher aromatic content fuels which tend to interact with the polar molecules of nitrile and swell the material.

AMS-P-5315, used to specify nitrile O-ring material, does not list a required range of acrylonitrile. However; it does list minimum requirements for hardness and elongation which should indirectly limit the minimum amount of acrylonitrile used in NBR which meets the requirements of the specification. The nitrile O-rings showed a proportional increase in volume swell versus aromatic content of the fuels tested. Standard JP-8, with an aromatic content of 19%, produced a positive volume swell of approximately 15%. JP-8/HRJ blended fuel, and JP-8/FT blended fuel with an aromatic content of 9.5%, produced a positive volume swell of approximately 7%, and neat HRJ and neat FT with an aromatic content of 0%, produced a positive volume swell of approximately 1% (22).

Additional accelerated soak testing of nitrile diaphragm material used in common control valves was performed by AFRL. At the end of a 56 day period the volume swell from JP-8 exposure was recorded at 1.9%, the volume swell from JP-8/HRJ blended fuel was recorded at 2.3%, and the volume swell from neat HRJ was recorded at 5%.

Available test results for nitrile O-rings, hose material, and control valve diaphragms indicate that these grades of nitrile are suitable for service in JP-8/HRJ blended fuel. The volume swell of nitrile used in O-rings and hoses increased with increasing aromatic content, and the volume swell of diaphragms decreased with increasing aromatic content. The negative volume swell documented for liners and hoses indicates that plasticizers and fillers used in these grades to

increase flexibility are being leached out of the softer materials over time. The leaching effect seems to be universal between exposures to JP-8, JP-8/HRJ blended fuel, and neat HRJ.

The performance of nitrile liners, hoses, and O-rings in JP-8/HRJ blended fuel is expected to be similar to nitrile performance in standard JP-8. However, these components have been shown to developed large volume decreases between exposures to standard JP-8 and JP-8/HRJ blended fuel and even developed negative volume swell in some cases. Nitrile liners, O-rings, and hoses may experience premature aging due to loss of plasticizers and reduced aromatic volume swell and require more maintenance over the lifetimes of the systems.

Nitrile is also suitable for service in neat HRJ, but the larger decrease in volume swell or negative volume swell would be expected to cause leaks if neat HRJ was introduced into in a system that was previously exposed to standard JP-8. Concerns regarding premature aging of nitrile would be elevated for it's use in neat HRJ systems and increased maintenance of the nitrile components over the lifetime of the system would be expected.

10.3.8 Silicone

"Silicone is a generic name for a wide variety of polymeric chains and networks constructed around a backbone of Si-O-Si" (57). "The silicone-oxygen bond has higher bond disassociation energy than a carbon-carbon bond. As a result, more energy is required to break the silicone-oxygen bonds than a carbon-carbon. This gives silicone rubber its high temperature resistance" (58). The bonds in silicone's backbone are all single bonds. The presence of nothing but single bonds is known as "main chain saturation" and is the primary reason why silicones are resistant to oxygen, ozone, and UV light (58).

There are five common silicone polymers currently in use. Standard methyl silicone (MQ) is composed of methyl groups (CH_3) attached to the silicone oxygen backbone chain. Vinyl methyl silicone (VMQ) is created by replacing a small number (typically less than 1%) of the pendent methyl groups in MQ with vinyl groups (CH_2CH). VMQ compounds tend to have better cure properties and undergo less compression set than standard MQ. Replacing 5% to 10% of the methyl groups with ringed phenyl groups (C_6H_6) results in phenyl methyl silicone (PMQ). PMQ has lower temperature properties than MQ or VMQ. Adding vinyl groups to PMQ results in phenyl vinyl methyl silicone (PVMQ). PVMQ has enhanced heat and radiation resistance (58). The final polymer is fluorovinylmethyl silicone (FVMQ) more commonly known as fluorosilicone rubber. Fluorosilicone is developed by replacing the methyl group on the standard silicone oxygen backbone chain with a combination of fluorine, vinyl and methyl groups (58).

Fluorosilicone shows superior resistance to many fluids including fuels due to the extremely polar fluorine element in the chemical structure. The other silicone polymers have poor compatibility with fuels. Particularly fuels with high levels of aromatic compounds. The higher the aromatic or phenyl content of oils and fuels the greater the effect on the other types of silicones (MQ, VMQ, PMQ, PVMQ) (59). MQ, VMQ, PMQ, & PMVQ are not compatible with fuel or aromatic compounds due to the large volume swell these materials exhibit, and these

materials are not used in fuel systems. PVMQ has been shown to swell as much as 330% in the presence of JP-4 (60). Fluorosilicone is a special case of the silicone group and will be reviewed in more detail in the next section.

10.3.8.1 Fluorosilicone (FVMQ)

Fluorosilicone elastomers combine the fluid and heat resistance of fluorocarbons and the low-temperature flexibility of silicone rubbers (61). Fluorosilicone rubber (FVMQ) is a high performance elatomer for applications requiring low temperature flexibility, high temperature stability, and fuel resistance (59). "Owing to very high poylymer volume cost FVMQ is used only where it's unique balance of properties is essential" (61). "Historically, fluorosilicones have not offered good short-term rebound resilience. When stretched to fit into male O-ring glands, fluorosilicone materials tended to sag rather than snap back tight against the groove" (62). "Fluorosilicone is primarily recommended for use in static seal applications. It's high friction characteristics, limited physical strength, and poor abrasion resistance make fluorosilicone inappropriate for most dynamic seals" (58).

Most compatibility charts list fluorosilicone as "Fair" for use in fuels and aromatics (56). This is due to a moderate amount of swelling experienced by fluorosilicones in fuels. Fluorosilicones typically experience around 10% swelling in fuels with only slight dependency on the aromatic content. FVQM test data is available for standard JP-8, JP-8/FT fuel blends, JP-8/HRJ fuel blends, neat FT, and neat HRJ. Testing in fuels that contained 0% to 19% aromatic content showed a volume increase change of around 1% (22).

Fluorine content of fluorosilicones has an impact on fuel resistance. Heat cured elastomers which typically have a fluorine content of around 37%, exhibit the volume swell characteristics listed above. While liquid fluorosilicones (FVMQ mixed with VMQ) with a fluorine content of around 21%, exhibit around twice as much volume swell (63). Typical fluorosilicone elastomers contain 30-40% fluorine (64). Specifying an FVMQ that meets one of the Type and Grade requirements of *SAE AMS-R-25988 Rubber, Fluorosilicone Elastomer, Oil-and-Fuel Resistant, Sheets, Strips, Molded Parts, and Extruded Shapes*, should yield an FVMQ with acceptable fuel and aromatic compatibility characteristics.

Studies have shown that fluorosilicone has been used in fueling nozzle O-rings (2).

Available test results for FVMQ O-rings indicate that these grades of FMQV are acceptable for service in JP-8/HRJ blended fuel and neat HRJ (56) (63) (64). The performance of fluorosilicone in JP-8/HRJ blended fuel and neat HRJ is expected to be similar to the performance of fluorosilicone in standard JP-8.

11. Compatibility of Miscellaneous Materials

11.1 Fiber Reinforced Plastic Pipe (FRP)

FRP piping materials are manufactured by winding processes that employ epoxy resins reinforced with continuous glass filaments. The resins used are thermosetting and undergo irreversible chemical reactions as they cure, resulting in superior temperature capabilities, while the filament reinforcement makes the piping components mechanically far more capable than ordinary non-reinforced thermoplastics. The result is enhanced performance and lighter weight (65).

Underwriters Laboratory has UL 971 Listed FRP piping for flammable and combustible service, and the 1996 edition of NFPA 30 references UL 971 and permits using FRP piping in fuel distribution terminals (65). UL 971 requires extensive testing of FRP pipe before it is Listed for use in underground fueling applications.

No test data is available for FRP pipe in JP-8/HRJ blended fuel or neat HRJ. Compatibility charts list the compatibility of FRP pipe in jet fuel, hexane, and heptanes service as recommended for temperatures of up to 150°F for all types of FRP pipe.

The performance of FRP pipe in JP-8/HRJ blended fuel and neat HRJ would be expected to be similar to the performance of FRP pipe in JP-8 service.

11.2 Cork

Cork is a natural material that was used as one of the first sealants and gaskets. Alternative materials have become substitutes for the more expensive cork, but it can still be found in some fueling systems. The cell structure of cork is a 14 sided polyhedron with its internal area completely empty which explains cork's exceptional compressibility. Cork has properties that include insulation, fire resistance, low rate of degrading, resistance to seepage, lightweight, buoyant, and effective at extreme temperatures (66). These properties made it the ideal candidate for early gaskets and other sealing agents.

Studies indicate that cork has been used as a gaskets material in fuel systems (2).

Accelerated soak tests were completed on cork-nitrile composite samples in standard JP-8, JP-8/HRJ blended fuel, and neat HRJ. At the end of a 56 day period the volume swell from JP-8 exposure was recorded at -0.3%, the volume swell from JP-8/HRJ blended fuel was recorded at -3.7%, and the volume swell from neat HRJ was recorded at -3.7%.

The volume swell of cork from exposure to JP-8 is similar to the volume swell of cork resulting from exposure to JP-8/HRJ blended fuel and neat HRJ. The performance of cork in JP-8/HRJ blended fuel and neat HRJ is expected to be similar to the performance of cork in HRJ.

12. Gap Analysis

Samples of the predominate seal, diaphragm, and hose materials used in fuel storage and transfer infrastructure are included in the “Short List” materials indentified in MIL-HDBK-510. The materials included in the “Short List” have been subjected to 28 days of accelerated soak tests in JP-8, neat HRJ, and JP-8/HRJ blended fuel in a combined effort between the University of Dayton and the AFRL (22). In most cases, resistance of the “Short List” materials to specific fuels correlated well with expected results. These results are based on the chemical composition of the test materials and HRJ.

Additional tests were conducted on Viton and nitrile control valve diaphragms and cork samples by the AFRL to answer questions regarding diaphragm material and cork compatibility with HRJ. Viton control valve diaphragm results matched previous results obtained from testing of Viton O-rings in standard and alternative fuels, while the nitrile diaphragm results showed opposite trends of volume swell versus fuel aromatic content from testing completed on nitrile O-rings. In both cases nitrile volume swell levels were similar for standard JP-8 and JP-8/HRJ blended fuels.

13. Conclusions

Material compatibility with JP-8/HRJ blended fuel and neat HRJ can be predicted by comparing the chemical composition of the material and the chemical composition of the alternative jet fuels. Actual test results, when available, can then be compared with expected results to develop strong relationships between the chemical composition of JP-8/HRJ blended fuel and neat HRJ and the chemical composition of the tested material. In most cases compatibility test results of the materials investigated in this report followed closely with the results that would be expected after exposure to JP-8/HRJ blended fuel and neat HRJ.

The majority of materials acceptable for use in standard JP-8 systems should exhibit similar acceptable performance in JP-8/HRJ blended fuels. The exception to this case is nitrile used in liners, O-rings, and hoses. These components developed large volume decreases between exposures to standard JP-8 and JP-8/HRJ blended fuel and even developed negative volume swell in some cases. Nirile liners, O-rings, and hoses should exhibit fair performance in JP-8/HRJ blended fuels, but may experience premature aging due to loss of plasticizers and reduced aromatic volume swell and require more maintenance over the lifetimes of the systems.

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Appendix D
Material Compatibility Matrix

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TABLE C3: MATRIX INDICATING THE COMPATIBILITY OF CURRENT AND FUTURE MILITARY FUELS WITH THE FUEL-WETTED MATERIALS FOUND IN MILITARY FUELING SYSTEMS

This table is primarily unpopulated at this time awaiting selection of candidate fuels

KEY

N	Incompatible
NS	Compatibility not suspect (Robert and Co.)
R	Prohibited or discouraged material
Y	Compatible

MATERIALS		FUELS																			
SHORTHAND	DESCRIPTION	KEROSENE										DIESEL									
			JP-8						JP-5				F-76			---					
		Prohibited or Discouraged	JP-8	JP-8+100	JP-8-SPK 50/50 USAF Study	JP-8-HRJ 50/50	HRJ	---	JP-5	---	---	Prohibited or Discouraged	F-76	---	---	---	---	---	---	---	---	---
METALS																					
Aluminium and Alloys																					
GENERIC			Y	Y	Y	Y	Y														
5083-H112	Wrought		Y	Y		Y	Y														
3003	Wrought		Y	Y		Y	Y														
3105	Wrought		Y	Y		Y	Y														
5010	Wrought		Y	Y		Y	Y														
5083	Wrought		Y	Y		Y	Y														
6061-T6	Wrought		Y	Y		Y	Y														
6063-T6	Wrought		Y	Y		Y	Y														
7120-T5	Cast		Y	Y		Y	Y														
3560-T6	Cast		Y	Y		Y	Y														
Cu, Zn, Sn, Ni and Alloys																					
Elemental																					
Cu	Copper	R	R	R	Y	R	R														
Zn	Zinc	R	R	R		R	R														
Brass																					
Cu-Zn	Brass	R	R	R	Y	R	R														
Cu-Zn-Pb-Sn	Naval Brass	R	R	R	NS	R	R														
Bronze																					
Cu-Sn	Bronze	R	R	R	Y	R	R														
Cu-Sn-Fe-C	Oilite Bronze	R	R	R	NS	R	R														
Nickel-Alloy																					
Ni-Cr-Fe	Inconel		Y	Y	Y	Y	Y														
Ni-Cu	Monel		Y	Y	Y	Y	Y														
IRON AND ALLOYS																					
IRON																					
Cast		R	Y	Y	Y	Y	Y														
Malleable			Y	Y		Y	Y														
Ductile			Y	Y	Y	Y	Y														
Fe-Ni-Cr (hard)			Y	Y		Y	Y														
Fe-Ni-Cr (resist)			Y	Y	Y	Y	Y														
CARBON STEEL																					
GENERIC			Y	Y	Y	Y	Y														
A53, A106, A333	Pipe		Y	Y		Y	Y														
A216	Cast fittings		Y	Y		Y	Y														
A105	Forged fittings		Y	Y		Y	Y														
ALLOY STEEL																					
A182	Forged fittings		Y	Y		Y	Y														
A234	Wrought fittings		Y	Y		Y	Y														
A434	Chrome-Moly		Y	Y		Y	Y														
STAINLESS STEEL																					
GENERIC			Y	Y	Y	Y	Y														
SAE 302			Y	Y		Y	Y														
SAE 303			Y	Y		Y	Y														
SAE 304L			Y	Y		Y	Y														
SAE 316			Y	Y		Y	Y														
A351 CF3M	Cast		Y	Y		Y	Y														
A351 CF8M	Cast		Y	Y		Y	Y														
POLYMERS																					
THERMOPLASTICS																					
PVC-TYPE																					
PVC	Polyvinyl chloride		R	R	Y	R	R														
EIA	Ethylene Isobutyl Acrylate																				
PA	Polyamide		Y	Y		Y	Y														
APA	Aromatic PolyAmide																				
POM	Polyoxymethylene, Polyacetal, Delrin, Celcon		Y	Y	Y	Y	Y														
PPS	Polyphenylene Sulfide																				
PMMA	Poly(methyl methacrylate), Acrylic																				
PS	Polysuphone																				
PE	Polyethylene																				
PET	Polyester, thermoplastic																				
PP	Polypropylene																				
FLUOROCARBON																					
PTFE	Polytetrafluoroethylene, Teflon		Y	Y	Y	Y	Y														
PTFE-filled			Y	Y		Y	Y														
PVDF	Polyvinylidene Fluoride																				
ECTFE	Ethylene chlorotrifluoroethlyene																				

TABLE C3: MATRIX INDICATING THE COMPATIBILITY OF CURRENT AND FUTURE MILITARY FUELS WITH THE FUEL-WETTED MATERIALS FOUND IN MILITARY FUELING SYSTEMS

This table is primarily unpopulated at this time awaiting selection of candidate fuels

KEY

N	Incompatible
NS	Compatibility not suspect (Robert and Co.)
R	Prohibited or discouraged material
Y	Compatible

MATERIALS: SHORTHAND	DESCRIPTION	FUELS: KEROSENE: Prohibited or Discouraged	JP-8: JP-8	JP-8: JP-8+100	JP-8: JP-8-SPK 50/50 (USAF Study)	JP-8: JP-8-HRJ 50/50	JP-8: HRJ	JP-8: ---	JP-5: JP-5	JP-5: ---	JP-5: ---	DIESEL: Prohibited or Discouraged	F-76: F-76	F-76: ---	F-76: ---	---: ---	---: ---	---: ---	---: ---	---: ---	---: ---	---: ---
THERMOSETS - HARD																						
PES	Polyester, thermoset		Y	Y		Y	Y															
PF	Phenolic																					
EPOXY																						
GENERIC					Y																	
Epoxy polyamide			Y	Y		Y	Y															
Epoxy phenolic																						
THERMOSETS-ELASTOMERS																						
GENERIC																						
BR	Polybutadiene																					
CR	Polychloroprene, Neoprene		R	R	Y	R	R															
CSM	Chloro Isobutylene Isoprene																					
ECO	Ethylene-Oxide-Epichlorohydrin																					
IR	Polyisoprene																					
SBR	Styrene Butadiene																					
BUTYL																						
IIR	Isobutylene Isoprene Butyl																					
CIIR	Chloro Isobutylene Isoprene																					
BIIR	Bromo Isobutylene Isoprene																					
EP	Ethylene Propylene																					
GENERIC																						
EPDM	Ethylene Propylene Diene Monomer																					
EPM	Ethylene Propylene Copolymer																					
FLUOROPOLYMER																						
FKM	Fluorinated Hydrocarbon, Viton		Y	Y	Y	Y	Y															
FFKM	Perfluoroelastomer, Kalrez		Y	Y		Y	Y															
FEPM	Aflas																					
NITRILE																						
NBR	Acrilonitrile Butadiene		Y	Y	Y	Y	Y															
HNBR	Hydrogenated Nitrile Butadiene		Y	Y		Y	Y															
XNBR	Acrilonitrile Butadiene Carboxy Monomer																					
POLYURETHANE																						
GENERIC					Y																	
AU	Polyester-urethane		Y	Y		Y	Y															
EU	Polyether-urethane																					
SILICONE																						
GENERIC																						
MQ	Methyl polysiloxane		N	N		N	N															
VMQ	Vinyl-methyl polysiloxane (Silicone)		N	N		N	N															
PVMQ	phenol-vinyl-methyl polysiloxane		N	N		N	N															
FVMQ	Fluoromethyl polysiloxane		Y	Y	Y	Y	Y															
PMQ	Phenyl-methyl polysiloxane		N	N		N	N															
MISCELLANEOUS																						
Concrete			Y	Y		Y	Y															
Calcium Chloride																						
Silicon Carbide					Y																	
Tungsten Carbide			Y	Y		Y	Y															
Loctite 242																						
Carbon			Y	Y	Y	Y	Y															
Cork			Y	Y	NS	Y	Y															
Paper			Y	Y	Y	Y	Y															
GLASS			Y	Y		Y	Y															
GENERIC																						
Borosilicate																						
Soda Lime																						
LUBES																						
Molybdenum disulfide																						
Teflon paste																						
Graphite					Y																	
FRP																						
GENERIC					NS																	
Matrix - Epoxy			Y	Y		Y	Y															
Matrix - Vinyl ester																						
Matrix - Polyester																						
COATINGS																						
METALLIC																						
Al	Aluminum																					
Cr	Chromium																					
Ni	Nickel				NS																	
Mo	Molybdenum																					
Cd	Cadmium	R			Y																	
Zn	Zinc		R	R		R	R															
Mn3O8P2	Manganese phosphate																					

TABLE C3: MATRIX INDICATING THE COMPATIBILITY OF CURRENT AND FUTURE MILITARY FUELS WITH THE FUEL-WETTED MATERIALS FOUND IN MILITARY FUELING SYSTEMS

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			JP-8						JP-5				F-76			---						
		Prohibited or Discouraged	JP-8	JP-8+100	JP-8-SPK 50/50 (USAF Study)	JP-8-HRJ 50/50	HRJ	---	JP-5	---	---	Prohibited or Discouraged	F-76	---	---	---	---	---	---	---	---	---
POLYMERIC																						
PE	Polyethylene																					
PU	"Polyurethane"				Y																	
PP	Polypropylene																					
Fluorocarbon																						
PTFE (Teflon)																						

EPOXY																						
GENERIC					Y																	
FBE	Fusion Bonded Epoxy (powder) coating																					
Epoxy polyamide			Y	Y		Y	Y															
PMEN	Polysulfide-modified epoxy novolac																					
Epoxy phenolic	Novolac																					
Coating A	NRL TLL-46 (UFGS 09 97 23.13)																					
Coating B	Epx-Epx-Epx USAF (UFGS 09 97 13.17)																					
Coating C	Epx-Epx-Fluorourethane (UFGS 09 97 13.15)																					
Coating D	Epx-PA USAF (MIL-PRF-4556)																					

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Appendix E
HRJ Filtration Report

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Sustainment Evaluation of API/EI 1581 Filter/Coalescer Performance with Hydro-Treated Renewable Jet and JP-8 Blended Fuel

Pond Project 1110033 - AFCESA HRJ Fuel Study

- **Air Force Civil Engineer Support Agency (AFCESA)**
  AFCESA Project AFCE-10-S-3128
  Contract FA8903-05-D-8737 – Task Order SK08

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Sustainment Evaluation of API 1581 Filter/Coalescer Performance with Hydro-Treated Renewable Jet (HRJ) and JP-8 Jet Blended Fuel

Executive Summary

Hydro-Treated Renewable Jet (HRJ) Fuel is a synthetic jet fuel being considered for use by the United States Air Force as well as other branches of the military and commercial aviation. The Air Force Petroleum Agency (AFPA) and Air Force Civil Engineer Support Agency (AFCESA) have been tasked with certification of the fuel for compatibility with existing fuels infrastructure. One step in this process is to perform an evaluation on the impact of the new fuel on existing filtration equipment with regard to the ability to effectively remove water and solids from the fuel. To perform this evaluation various tests were performed following the API/EI 1581 5th Edition “Specifications and Qualification Procedures for Aviation Jet Fuel Filter Separators” with a variety of fuels and filters.

In the first phase of testing three groups of tests were performed, each to evaluate different potential effects of the new fuel:

- Soak Test: This series of tests is focused on evaluating basic material compatibility by immersing the assembled filters in fuel for 28 days, after which evaluating the elements for degradation in construction.
- Water Coalescing Effectiveness: This series of tests compared the water coalescing effectiveness of new clean filter elements to that of elements from the Soak Test phase. The intent is to determine if there was any significant change in the performance of the coalescer after immersion.
- Overall Filter/Coalescer Performance: This series of tests was the most rigorous, following the API/EI 1581 single element protocol to determine if the fuel blend altered the solids/water removal performance of several filter/coalescer elements.

The general conclusions from the first round of testing are as follows:

- There were no notable concerns from the “Soak Test” testing. Exposure had limited effect on the various elements during the immersion period.
- There was no significant affect on the results with the addition of +100 additives or the use of filters rated for +100 fuels.
- There was no measurable change in coalescing performance between new and aged elements as defined in this study. The application of this conclusion is limited in that “aged” did not include exposure other than immersion.
- Within the standard operational range of differential pressures as defined by the filter manufacturers and UFC 3-460-03 (typically 15 psi), all variations of fuels and filters did effectively remove water and solids from the fuel stream. However, the introduction of HRJ into the fuel blend did result in higher differential pressures compared to straight petroleum JP-8 during the testing.

- Failure to monitor differential pressures (DP) during operations can result in filter element failure and water contamination of fuel downstream of filtration. This is more of a concern where 5th edition elements have been installed in systems certified under the 3rd edition of the standard where the flow through the elements may be higher.

In order to provide a more definitive evaluation of the impact of the additives on the fuel a second phase of filtration tests were performed. In general the tests followed the API /EI 1581 5th edition single element protocol, with petroleum JP-8 and a 50/50 blend of HRJ and petroleum JP-8 with the additives being varied as outlined below.

1 – No additives
2 – Static Dissipater Additive (SDA)
3 – Fuel System Icing Inhibitor (FSII)
4 – Corrosion Inhibitor/Lubricity Improver (CI/LI)
5 – SDA – FSII
6 – SDA – CI/LI
7 – FSII – CI/LI
8 – SDA – CI/LI – FSII
9 – Same fuel as test 8 except run 50/50 mix A1 and A3 silica (no red iron oxide as solids challenge and of only run 0.5% water in final challenge

A tenth test was performed using the fully additized fuel (same as test 8) except at the same flow rates as the Phase I testing. The results from this test matched the results of the Phase I test which validates combining the two data sets for consideration.

The conclusions from the second phase of testing are as follows:

- The ability of the 5 h edition M filter elements to remove water and solids from the fuel was not significantly affected by the addition of HRJ to the fuel blend with any combination of additives.
- The addition of HRJ to the blend of fuel does result in an increase in differential pressures at key stages of the testing for both neat and fully additized fuels. The change due to the addition of HRJ was roughly the same in both tests, about 3 psid.
- The tests with the individual additives counteracted the impact of the addition of HRJ resulting in test curves that are virtually the same with or without HRJ.
- The combination of additives varied in effect. Only the combination of SDA and FSII increased the effect of adding HRJ to the blend.
- The removal of the red iron oxide from the solids challenge resulted in an increased DP during the second water challenge which was the opposite of the expected results. The addition of HRJ to the fuel blend was highest in this test (almost 8 psid at the end of the second water challenge).

Flow rate through the filters is an important factor when performing these tests. Typically, in order to qualify under the 5th edition M requirements the flow rates are lower (per inch of effective length) than a 3rd edition element. The first phase of testing was performed at roughly 34 gallons per minute which in on the high end of the typical 3rd edition performance range. The

second phase of testing was run at roughly 26 gallons per minute which is slightly lower than the maximum for a typical 5th edition M element. Establishing the correct flow varies with the type of element being used and the manufacturer. Additional testing was performed to correlate the values from the two test phases and allow consideration of the higher flow rates.

An additional conclusion was derived from the additional tests:

- Operating 5th edition M elements above the manufacturer's defined range will result in higher differential pressures during all phases of the test. This can become a factor when 5th edition elements are installed in 3rd edition vessels.

Recommendations

- Develop and Engineering Technical Letter (ETL) for the introduction of HRJ into fuel systems that reinforces the importance of monitoring differential pressures in filtration systems. The introduction of HRJ will result in higher DP measurements through "dirty": filtration.
- Review the standard process for upgrading filtration elements in older vessels to ensure the rated flow is not exceeded for the new elements as this can result in reduced performance of the filtration system as opposed to the anticipated improvement.

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Sustainment Evaluation of
API 1581 Filter/Coalescer Performance with
Hydro-Treated Renewable Jet (HRJ) and JP-8 Jet Blended Fuel

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Sustainment Evaluation of
API 1581 Filter/Coalescer Performance with
Hydro-Treated Renewable Jet (HRJ) and JP-8 Jet Blended Fuel

1.0 Background

Office of the Secretary of the Air Force (SECAF) has established a goal of 2016 for the United States Air Force (USAF) to be prepared to cost competitively acquire 50% of its domestic aviation fuel requirement via an alternative fuel blend with the alternative component derived from domestic sources producing fuel in a more environmentally-friendly manner than conventional petroleum production. Hydro-Treated Renewable JP-8 Jet Fuel (HRJ) is a synthetic fuel that is produced from bio-based feedstocks. The Air Force desires to certify all air frames by 2012 and be able to purchase 400 million gallons per year of alternative fuel blends by 2016.

It is the intent of the government to utilize HRJ as a blend stock with petroleum jet fuel to help achieve the sustainment goals outlined above. Prior evaluations of the fuel indicate several differences in the chemical composition of HRJ compared to petroleum jet fuels that have an impact on the use of the fuel in aircraft. As a result the plan is to utilize at most a blend of 50% HRJ to petroleum jet in the supply chain. Given this, existing USAF infrastructure will be exposed to blends of all ratios up to 50/50, but should not be exposed to neat HRJ.

Air Force Petroleum Agency (AFPA) and Air Force Civil Engineer Support Agency (AFCESA) desire to certify existing fuels infrastructure for use of HRJ/JP-8 blended fuels. Part of this certification is to investigate the effects of HRJ/JP-8 blended fuels on fuels system components such as pumps, control valves and pressure flow sensors. As part of this process, AFCESA contracted with Pond & Company to perform a series of evaluations and tests to ensure compatibility with existing fuel infrastructure. One phase of the evaluation focused on the effect on filtration systems presently in use both CONUS and OCONUS.

In the handling of jet fuel from the point of receipt to the aircraft, the Department of Defense (DoD) and the USAF utilize several layers of fixed and mobile filtration systems to ensure the cleanliness and quality of the fuel. The specifications for the fuel being delivered are strict relative to several performance characteristics of the fuel and the cleanliness of the fuel. Filtration systems exist on all inbound sources and at least two layers of filtration exist between on site storage and the skin of the aircraft. These systems are relied upon to remove water and solids from the fuel stream prior to entering the aircraft fuel tank. This focus on fuel cleanliness is critical to proper performance of the aircraft engines.

The American Petroleum Institute (API) and Energy Institute (EI) 1581 standard, “Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators” is

the world's commercial specification for aerospace for removal of solids and water contamination from aviation fuel. The current revision of this standard is API/EI 1581 5th Edition, July 2002, and specifies the minimum performance and mechanical requirements and the testing and qualification procedures for aviation jet fuel filter/separators utilized in both commercial (Category C) and military (Category M and M100) applications. The current design standard in use calls for API/EI 1581 5th edition filtration, there are several systems in use that were constructed and still utilize 3rd edition filtration systems.

The API/EI 1581 standard was developed with the intent to simulate extreme conditions in a very short period of time to evaluate the effects of water and solids in the fuel stream and the ability of the filtration elements to prevent flow of these contaminants downstream into aircraft. To make the test reproducible, it provides specific parameters on the type, concentrations and injection method of solids to be used, percentages and injection methods for the water and durations for each phase of the test. The standard provides pass/fail criteria for filters being considered under the standard. The parameters have evolved over the five editions in an attempt to make the exposures as close to "real world experience" as possible, while also attempting to accelerate the results.

While this standard was developed for the testing and certification of various filters, it provides a solid basis for evaluating changes in filtration performance based upon different fuels and additives.

2.0 Objectives

This project is designed to perform a sustainment engineering evaluation of the material compatibility and impact on water and solids removal performance of an additized Hydro-Treated Renewable (HRJ) jet and M-category fuel blend on an API/EI 1581 3rd Edition, API/EI 1581 5th Edition Category M, and API/EI 1581 5th Edition Category M100 filter coalesce/separators.

The objectives of this sustainment engineering program are to:

- Evaluate the material compatibility of an additized HRJ fuel and standard M-category fuel blend on a clean, new API/EI 1581 3rd and API/EI 1581 5th Edition filter coalescers.
- Evaluate the impact on water coalescing effectiveness of a single clean, new and used API/EI 1581 3rd and 5th Edition filter coalesce elements by an additized HRJ fuel and standard M-category fuel blend.
- Evaluate the impact of an additized HRJ fuel and standard M-category fuel blend on a clean, new API/EI 1581 3rd and 5th Edition M and M100 filter coalesce/separator systems to determine if it alters the solids/water removal performance.

- Evaluate the influence of the various additives on the performance of the filtration with HRJ fuel.

As the Defense Logistics Agency (DLA) Energy and the DoD pursue procurement and introduction of HRJ blends into the DoD bulk fuels supply chain, the impact on filtration systems meeting API/IP 1581 5th/3rd editions must be determined to influence decisions on the type of filtration systems purchased.

3.0 Phase I Approach

The Phase I project approach was defined in the Project Scope of Work dated 28 July 2010, more specifically Appendix A which is titled “HRJ Filtration Sustainment Engineering Performance Work Statement”. This document provided specific direction on the tests, but was expanded through the course of the evaluation to include additional tests and evaluation of prior test results. Pond & Company contracted with Southwest Research Institute (SwRI) for the purpose of performing the testing. The JP-8 and HRJ fuels were supplied in separate shipments by the USAF and were blended in a single tank at SwRI upon receipt. In addition, smaller volume drum samples of each fuel were received for use in the immersion testing.

3.1 Materials

3.1.1 Test Fuel

7,500-gallons each of JP-8 and HRJ test fuel was provided by USAF for these evaluations. Each fuel was delivered separately and blended in the SwRI 20,000-gallon storage tank for a total of 15,000-gallons of test fuel. To insure all of the evaluations were performed in a systematic manner, the test fuel was first water washed to remove the fuel system icing inhibitor (FSII). Once the FSII was removed, the excess water/FSII was removed using the coalescer cleanup filters, the fuel was clay-treated to remove the conductivity, corrosion inhibitor, and other additives such as +100 thermal conductivity additive. Once the conductivity was below 20 pS/m, the fuel was ready to be re-additized to meet the test matrix fuel chemistry. This process to remove the fuel additives was performed after each evaluation.

The average MSEP values for these fuels were;

- Clay-treated HRJ/JP-8 (without any additives) – 98
- 50/50 HRJ/JP-8 (with M category additives) – 76
- 50/50 HRJ and JP-8+100 (with M100 additives) – 0

3.1.2 Fuel Additives

The fuel additives utilized for this program are those approved by API/EI 1581 5th Edition and MIL-DTL-83133. The additives utilized for this program were:

- Stadis 450 static dissipater additive (SDA)
- DCI4A corrosion inhibitor/lubricity improver (CI\LI)
- Di-ethylene glycol mono-methyl ether (Di-EGME) fuel system icing inhibitor (FSII)
- SPEC AID 8Q462 thermal stability additive (+100)

3.1.3 Filter Elements

The filter element types for the project were defined in the SOW. The three categories of filter elements to be used included API/EI 1581 3rd edition, API/EI 1581 5th edition M category and API/EI 1581 5th edition M100 category elements. The element size was dictated by the test apparatus used for the filtration testing. The single element test rig at SwRI is designed to accept a standard filter size as is typically used in truck filtration units. The filter/coalescer element size is 6” diameter x 14” long (effective length varies but is roughly 12”).

During the course of the testing, the primary source for the filters was Velcon Filters, LLC. However additional testing was also performed with elements from Facet International. The filters used during the testing were:

API/EI 1581 3rd edition	Velcon I61487TB	
API/EI 1581 5th edition M	Velcon I614MMTB	Facet TC-C0162
API/EI 1581 5th edition M100	Velcon 614A4TB	

3.2. Material Compatibility

In order to evaluate the material compatibility of standard filter elements in additized HRJ fuel and standard M-category fuel blends, representative samples of the various elements were immersed in both fuels. The evaluation followed API/EI 1581 5th edition, paragraph 4.6.2 modified to only include the fuels being considered in this study. A matrix of the tests is shown in Table 1.

Table 1

	HRJ*	**50% HRJ/50% JP-8***
API/EI 3rd Edition Filter	X	X
API/EI 5th Edition M Filter	X	X
API/EI 5th Edition M+100 Filter	X (w/ +100)	X (w/ +100)

* fuel was additized with FSII, CI/LI and SDA as per JP-8 standard

The fuel used in the immersion tests was pulled from drum samples of fuel provided by the USAF. The HRJ was additized after receipt in drums. The 50/50 blend was pulled from the large storage tank after the fuels were received, blended, cleaned and re-additized.

As defined in the standard, filter elements were placed in stainless steel containers and fully immersed in fuel for a period of 336-hours (14 days), drained for 4 hours and subjected to a second soak period of 336-hours (14 days) for a total soak period of 672-hours (28 days). After immersion the fuel and the elements were inspected for visual signs of degradation. In addition, the following tests were performed at the end of the test period:

a) MSEP(ASTM D 3948)
b) Existent gum (ASTM D 381 (Steamjet))
c) Water reaction (ASTM D 1094)
d) Detailed inspection and description of all component parts
e) Color (ASTM 0156).

The filters immersed in HRJ, were retained and used in the water coalescing effectiveness tests.

3.3 Water Coalescing Effectiveness

A new test protocol was proposed and accepted to evaluate the impact on water coalescing effectiveness of a single clean, new and aged API/EI 1581 3rd and 5th Edition filter/coalescer elements by an additized HRJ fuel and standard M-category fuel blend. The primary intent was to compare the data from a new clean element to an element that had been immersed for 28 days in neat HRJ (aged).

The summary of the test protocol is provided below with the complete description provided in the Appendix B, Test Protocol for Evaluating Stored test Elements:

- Clean, dry test fuel at rated flow for 30 minutes
- 100-ppm water challenge for 20 minutes
- 1% water challenge for 20 minutes

- 19 mg/L solids contamination to a maximum of 45 psid
- Structural evaluation to 75 psid
- Test terminated once performance exceeded API/EI 1581 5th Edition water or solids specifications

The intent was to develop a procedure that could be repeated without extending the test to the full single element test. This approach allowed for both observation of the coalescing water droplets on the elements, but also provided for some recorded information including differential pressure and water contamination downstream of the filter.

3.4 Overall Filter/Coalescer Performance

This series of tests was the most extensive and complex portion of the filtration evaluations. Using the API/EI 1581 5th edition single element protocol (section 4.3), a variety of filter elements were exposed to different fuel combinations. The goal was to evaluate the impact of an additized HRJ fuel and standard M-category fuel blend on API/EI 1581 3rd and 5th Edition M and M100 filter coalesce/separator systems to determine if it alters the solids/water removal performance.

To insure all of the evaluations were performed in a systematic manner, the test fuel was first water washed to remove the fuel system icing inhibitor (FSII). Once the FSII was removed, the excess water/FSII was removed using the coalescer cleanup filters, the fuel was clay-treated to remove the conductivity, corrosion inhibitor, and other additives such as +100 thermal conductivity additive. Once the conductivity was below 20 pS/m, the fuel was ready to be re-additized to meet the test matrix fuel chemistry. This process to remove the fuel additives was performed after each evaluation.

The initial program called for performing the single element tests with the API/EI 1581 3rd edition and 5th edition M elements using a 50/50 blend of HRJ and JP-8. The test fuel was to be additized in accordance with the JP-8 standard using FSII, CI/LI and SDA. The API/EI 5th edition M100 element test was performed using the same 50/50 additized blend with addition of the +100 additive. During the test, variations on the base scope were completed including performing a test using clay treated (un-additized 50/50 blend of HRJ and petroleum jet).

4.0 Phase II Approach

The second phase of testing was initiated as a modification to the contract as a result of the Phase I results. The Phase II project approach was defined in the Project Scope of Work dated 2 February 2011, more specifically Appendix D.. This document provided specific direction on the tests, but was expanded through the course of the evaluation to include additional tests and evaluation of prior test results. Pond & Company contracted with Purolater Facet, Inc. (Facet) for the purpose of performing the testing. The JP-8 and HRJ fuels were supplied in separate shipments by the USAF and were blended in a single tank at Facet upon receipt

4.1 Materials

4.1.1 Test Fuel

6,500-gallons each of JP-8 and HRJ test fuel was provided by USAF for these evaluations. Each fuel was delivered separately and blended in the Facet 15,000-gallon storage tank for a total of 13,000-gallons of test fuel. Samples of the individual fuel deliveries were collected and sent to Wright Patterson AFB as required in paragraph 3.8 of the SOW.

To insure all of the evaluations were performed in a systematic manner, the test fuel was first water washed to remove the fuel system icing inhibitor (FSII). Once the FSII was removed, the excess water/FSII was removed using the coalescer cleanup filters, the fuel was clay-treated to remove the other additives. Once the conductivity was below 20 pS/m, the fuel was ready to be re-additized to meet the test matrix fuel chemistry. This process to remove the fuel additives was performed after each evaluation.

Samples of the fuel were collected after each test was performed. The samples were labeled to indicate the test run and date. Each of these samples was shipped to Wright Patterson AFB for testing as determined necessary by AFPET.

4.1.2 Fuel Additives

The fuel additives utilized for this program are those approved by API/EI 1581 5th Edition and MIL-DTL-83133. The additives utilized for this program were:

- Stadis 450 static dissipater additive (SDA)
- DCI4A corrosion inhibitor/lubricity improver (CI\LI)
- Di-ethylene glycol mono-methyl ether (Di-EGME) fuel system icing inhibitor (FSII)

4.1.3 Filter Elements

The filter elements for this phase of testing were all 5th edition M class elements. All were model number TC-C0162 as manufactured by Facet in the same manufacturing lot. The element size was dictated by the test apparatus used for the single element filtration testing. The single element test rig at Facet is designed to meet the 5th edition spacing requirements and accepts a filter/coalescer element 6” diameter x 14” long (effective length approximately 11.7”)

4.2 Single Element Test

The Phase II testing followed the standard protocol outlined in API 1581 5th edition for single element testing. This procedure includes four stages of exposure or challenges to the filter performance.

- Initial conditioning full flow with clean fuel to saturate element and establish steady state conditions (typically about 10 minutes)
- Water coalescing test: 0.01% water for 30 minutes
- Solids holding test: 19 mg/l solids (solids are a blend of 10% Copperas red iron oxide R-9998 and Arizona Test Dust ISO 12103-1, A1 silica) for 75 minutes or until differential pressure reaches 22.5 psid with pump stop start every fifteen minutes
- Water coalescing test: 0.01% water for 150 minutes with pump stop start every thirty minutes
- Water coalescing test: 3% water for 30 minutes with pump stop start every ten minutes

The protocol is a pass/fail evaluation of filtration system effectiveness. For this evaluation the comparison to pass/fail is important, however the comparison of the data with and without the HRJ component is equally important.

The variable for most of the tests is the fuel blend. The tests will be performed with no additives, then with each of the additives used to satisfy the JP-8 specification as outlined above. Table 2 outlines the tests to be performed.

Table 2

	Petroleum JP-8	50% HRJ/50% JP-8*
Neat fuel (no additives)	1	1H
SDA only	2	2H
FSII only	3	3H
CI/LI only	4	4H
SDA and FSII	5	5H
SDA and CI/LI	6	6H
CI/LI and FSII	7	7H
SDA, CI/LI and FSII	8	8H

In addition to the tests outlined above test 9 and 9H were also performed following the same general procedure outlined above except the solids was changed to a 50%/50% mixture of Arizona Test Dust A1 and A3 size silica. No red iron oxide (RIO) was introduced. In addition, the 3% water in the final stage of the test was reduced to a 0.5% water to closer simulate real world conditions. The intent of removing the RIO was to evaluate the influence of this solid since prior reports on SPK and other additized petroleum fuels indicated this solid reportedly affected differential pressures during prior single element testing.

Finally a test 10 and 10H were also performed to validate the values measured at higher flow rates in Phase I testing performed at SwRI. Phase I tests were performed at a flow rate of 34 GPM. This rate was challenged by the manufacturers during review of the results of the first tests, stating it exceeded the maximum flow recommended for a 1581 5th edition M element. In order to ensure statistically valid comparisons between tests performed at different facilities, the higher flow rate tests were repeated for comparison with the Phase I results to ensure the comparison of results was valid.

During all tests various properties were measured and recorded as outlined by the protocol including differential pressure, water concentration in the effluent, solids in the effluent, fuel temperature and water droplet size. At the beginning of each test run MSEP was also recorded using ASTM D3948 as prescribed by the 1581 procedure.

After each test a sample was collected and the fuel was then cleaned using a combination of water wash and clay treatment to remove the additives from the prior test run. The fuel was then additized as needed for the next test.

5.0 Discussion

5.1 Material Compatibility (Phase I)

The initial immersion or soak tests were performed in accordance with API/EI 1581 5th edition, paragraph 4.6.2. The three element types were immersed in additized HRJ and 50/50 blend of HRJ and JP-8. The HRJ was pulled from drums provided by AFPA while the blended fuel was pulled from the bulk tank used for the filtration tests.

There were no visible signs of degradation or damage to any of the filter elements during the visual inspections at the end of the immersion period. The elements that had been in additized HRJ were used in the water coalescing effectiveness tests outlined in the next phase of the study. None of the elements demonstrated a loss of structural integrity or decreased DP resistance from the immersion process.

The tests outlined in the standard relate to samples of the fuel pulled after the immersion. Specifically the tests consider the effect of the filter on the fuel quality. The results for this are included in Appendix C of this report.

5.2 Water Coalescing Effectiveness (Phase I)

As stated, the procedure for the water coalescing effectiveness was derived from a protocol developed by SwRI as an abbreviated version of the single element test. The procedure was originally developed to evaluate life extension of in-service filter elements. In discussions with AFPA, the intent of this phase of testing was to compare a filter element that had been exposed to the test fuel, with elements that had not to see if the exposure affected the element's coalescing effectiveness. The selected protocol was more detailed than the original approach discussed at the kick off meeting, but provides measureable and repeatable results as opposed to being subjective. The complete procedure is included as Appendix D of this report.

The test evaluation includes visual monitoring of the water coalescing from the outer surface of the filter element. Considerations of water droplet size are subject to the operator, however in our situation the primary goal is comparison of the “aged” element to a new, clean one. The aged elements were those exposed to the neat HRJ fuel in the immersion test in the first phase of this study. These elements had been exposed to clean HRJ for twenty-eight (28) days.

5.2.1 API 1581 3rd Edition Element

Both the new element and the aged elements had very similar filtration and operating performance during the clean fuel and 100-ppm water challenge. Both evaluations failed the 1% water contamination challenge at the 5 minute data point. The differential pressure at the time of failure for both the new and aged element was 12.4 psid and 11.5 psid, respectively. The water removal performance for both elements was below 1-ppm until the 1% water challenge and subsequent failure. The Results are shown in Figure 1.

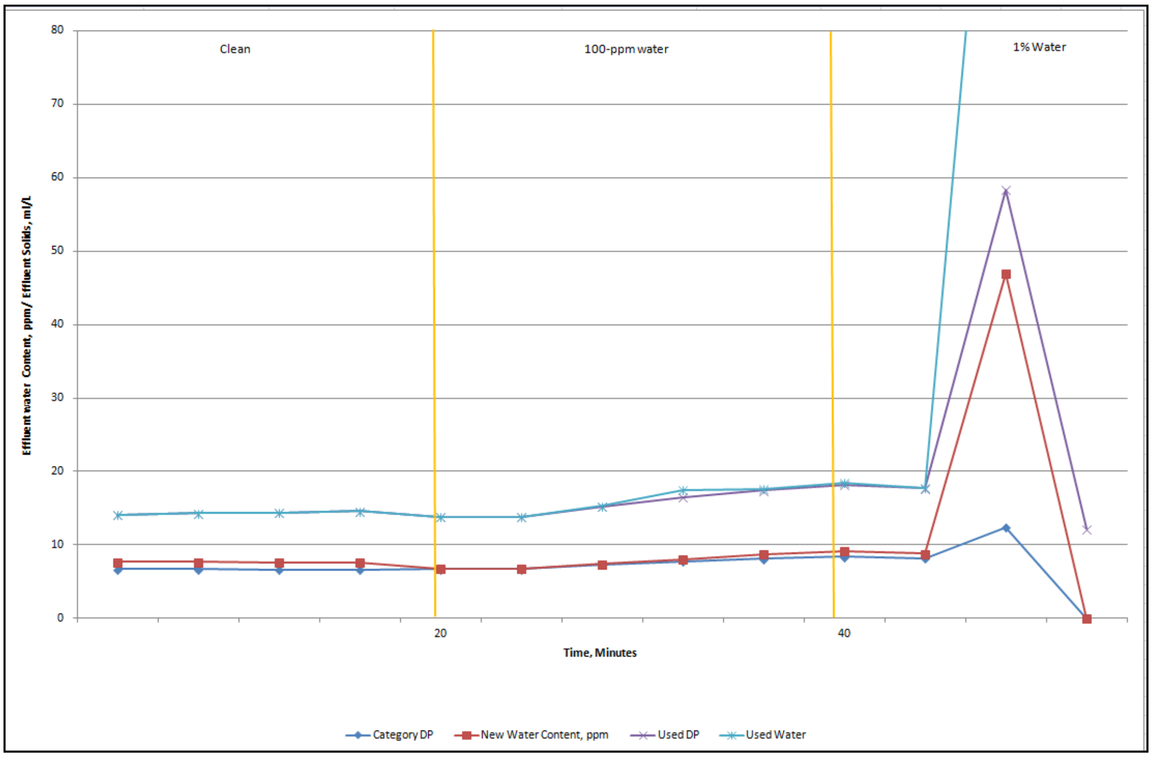

Figure 1 – 3rd Edition Elements Material Compatibility in 50/50 HRJ/JP-8 Fuel Blend

There was no significant difference in the operational effectiveness of the new versus aged elements. The test procedure was stopped during the 1% water challenge because the water contamination downstream of the filter exceeded the limits allowed by API/EI 1581.

5.2.2 API/EI 1581 5th Edition Category M

The results for the API/EI 1581 5th Edition category M with 50/50 HRJ/JP-8 were very similar to the API 1581 3rd Edition results. Both the new and aged elements had similar filtration and operational performance during the clean and 100-ppm water challenge.

The aged element initial differential pressure was slightly higher than the new (0.6 psid), but it is not known if that is due to the aging or the manufacturing variability. The effluent water contents for both the new and aged elements for the clean and 100-ppm water challenge were less than 1-ppm. Both elements failed the effluent water content at the 5-minute reading with the 1% wat er challenge. The results are shown in Figure 2.

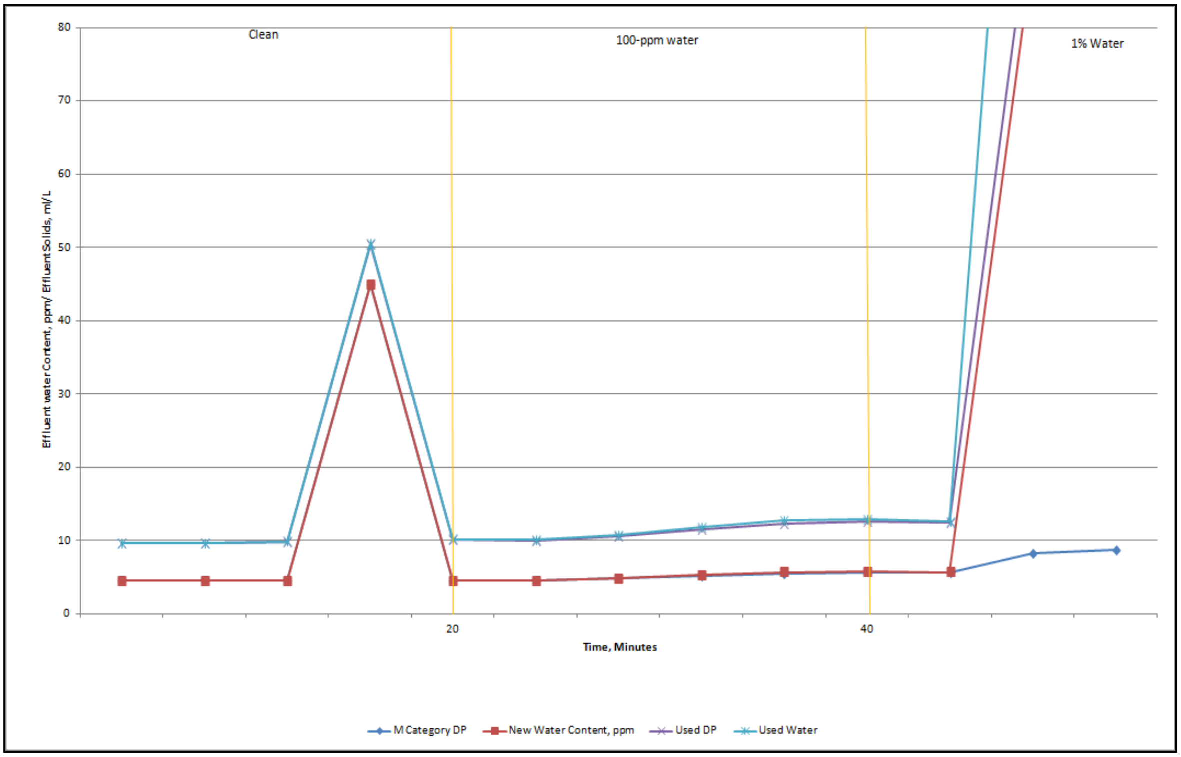

Figure 2 – Category M Elements Material Compatibility in 50/50 HRJ/JP-8 Fuel Blend

Similar to the 3rd Edition elements, there was no significant difference in the operational capability of the new versus aged elements.

5.2.3 API/EI 1581 5th Edition Category M100

The M100 elements were tested with a blended fuel that included the +100 additive, otherwise the procedures were the same as the previous evaluations in this phase of the study. The results for the M100 new element completed the designed test matrix without the effluent water or solids being out of specification. The structural pressure of 75 psid was reached after a total of 95 minutes without failure. The aged element failed after at the 5 minute data point at the 1% water challenge similar to both the 3rd edition and 5th edition M category evaluations. This evaluation does demonstrate a difference in the filtration performance and compatibility between the constructions included in this project. The test results are shown in Figure 3.

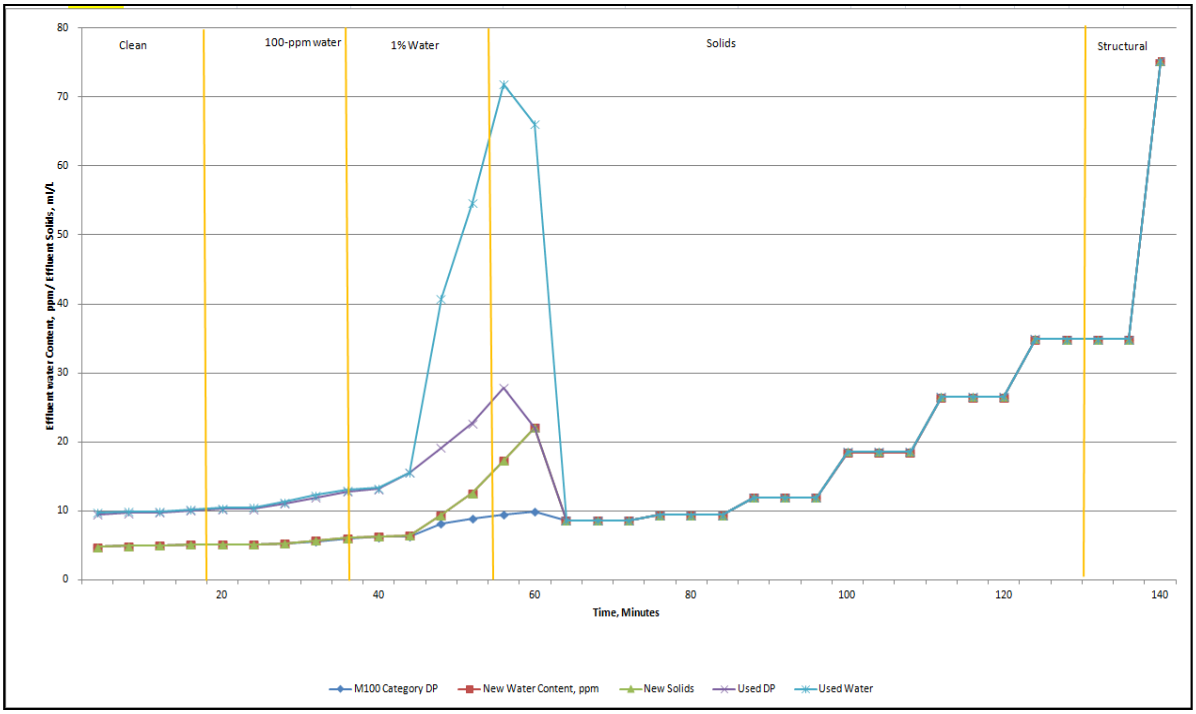

Figure 3 – Category M100 Elements Material Compatibility in 50/50 HRJ/JP-8 Fuel Blend

5.2.4 Analysis

Overall the new versus aged elements performed in a similar manner. Comparison of the water coalescing effectiveness between new and aged filters did provide some evidence that there is a slight decrease in the aged elements. The results through the 100 ppm challenge, which is a more realistic exposure did not show any significant difference. A difference was not noted until the water levels were increased to 1%. At this level the differential pressures and water contamination in the effluent both spiked. With the 3rd edition and 5th edition M category elements, the values exceeded limits causing the test to be stopped.

The only category that offered measurably different results was the API/EI 1581 5th edition M100 elements where the new element was capable of proceeding through the entire procedure without failure. The aged M100 element also performed better than the previous elements through the 1% water challenge, even though the effluent water contamination exceeded the 15 ppm limit.

It must be pointed out that this test exceeds parameters anticipated in field conditions with regard to fuel quality and water content. The failures of the elements in this procedure do not equate to failure under the certification procedure defined by the referenced standards. The intent of this test is comparison of the coalescing effectiveness only.

5.3 Filter/Coalescer Performance (Phase I)

In the performance of this series of tests several observations were made beyond the original intent of the tests. The first was the conductivity measurements of the fuel were outside of the anticipated range. The second obervation was that the differential pressures during the various stages of the tests were higher than typically measured during testing in previous projects performed by SwRI..

The API/EI protocol defines parameters to be measured before during and after the testing. One of the characteristics of the fuel to be documented is the conductivity. In virtually every test the measured values at the time of the test were lower than anticipated values based upon experience with petroleum based jet fuels. Normal conductivity with 2 mg/L SDA is in the 1,000-1,200 pS/m. The conductivity for the 50/50 HRJ/JP-8 blend was less than 600 pS/m.

The higher differential pressures were noted in virtually every phase of the testing. The differences are low in the early phases of each single element test, however they increased dramatically in the later phase of the testing. This relationship is based upon comparison of data from prior testing by SwRI beyond the scope of this project. It is noted that the flow rates used in the earlier tests were the same (i.e. 34 GPM). The primary conclusion from this event is that HRJ does increase the differential pressures above that typically noted with standard petroleum based JP-8.

5.3.1 API 1581 3rd Edition Element

The first evaluation in the scope of work was the evaluation of the API 3rd Edition element using the 50/50 HRJ/JP-8 blend. The conductivity values measured in the fuel at the beginning of the test were approximately half the expected values, and increasing differential pressures early in the second 100-ppm water challenge (approximately 120 minutes) were noted.

For the first water contamination and solids challenge, the differential pressures were only slightly higher than typical values. However, once the second water 100-ppm water challenge was initiated, the differential pressure was significantly higher. The solids removal characteristics were good with a maximum value of 0.050 mg/L. The water removal failed the criteria after the differential pressure reached over 45 psid, by allowing more than 15 ppm water measured downstream of the filter. It should be noted that the element being tested is not qualified under the 5th edition criteria under normal circumstances.

The increased in differential pressure is shown in Figure 4, being the highest values of the evaluations performed during the project. The effluent water content is shown in Figure 6.

5.3.2 API/EI 1581 5th Edition Category M Element

The second set of evaluations was the API/EI 1581 5 h Edition category M with the 50/50 HRJ and JP-8 blend. During this evaluation, the same discrepancies were seen from “typical” API/EI 1581 5th Edition evaluations from SwRI’s experience. For the first water

contamination and solids challenge, the differential pressures were only slightly higher than typical values. However, once the second water (100-ppm) challenge was initiated after the solids, the differential pressure was significantly higher. Once the 3% water challenge was introduced, the differential pressure increased to the point where the structural integrity of the element failed (>75 psid).

The test filter had good water removal characteristics until the end of the second 100-ppm water data point (150 minute stop/start) when the effluent water content was measured at 15 ppm (differential pressure at failure was almost 30 psid). Once the 3% water challenge was introduced, the values were off-scale even with a 100-mL effluent sample. The solids removal characteristics were good with a maximum effluent solids content of 0.075 mg/L.

5.3.3 API/EI 1581 5th Edition Category M100 Element (with +100 blend)

The third evaluation was the API/EI 1581 5th Edition category M100 element with 50/50 HRJ/JP-8+100 blend. The conductivity values were actually lower than with the previous evaluations (490/420). The expected values are in the 700-800 pS/m range.

The differential pressure did increase more than expected, but not as much as shown in the 5^{h} M and 3rd category evaluations, Figure 2. The effluent water content was good for during the evaluation up to 2 minutes into the 3% water challenge when the element failed adjacent to the end cap (approximately 60 psid), Figure 6. The solids removal characteristics were slightly higher than the 5th M and 3rd category evaluations, but still within specification with the maximum value being 0.15 mg/L.

5.3.4 Supplemental Evaluations

Additional tests were performed to determine if the fuel or the test elements were the problem. The first additional evaluation was to perform an API/IP 1581 5th Edition evaluation using a Velcon element from a different lot as well as an element from a different supplier. SwRI had previously performed testing with this element lot using 5th M category petroleum jet fuel with positive results and the test filter passed all sections of the test protocol.

5.3.4.1 API/EI 1581 5th Edition Category M Element (Different Lot)

This evaluation utilized the API/EI 1581 5th Edition category M element from the old production lot (12/07/09) using 50/50 HRJ/JP-8 blend. This evaluation had similar results to the test with the new lot M category element. The differential pressure increased similar to the original results if not higher than the original evaluation. The effluent water content failed during the second water challenge (approximately 75 minute), Figure 4. The solids removal results were good with the maximum effluent solids content of 0.05 mg/L.

5.3.4.2 API/EI 1581 5th Edition Category M (Facet)

An additional filtration evaluation was API/EI 1581 5th Edition category M with 50/50 HRJ/JP-8 blend, but the coalescer was a Facet element as opposed to Velcon. The

objective of this evaluation was to determine if the results of the previous evaluations was a function of the Velcon manufacturing process.

The differential pressure increased sooner than what was noted during the Velcon tests beginning the rise during the solids challenge, eventually to the minimum structural limits of the element (75 psid), Figure 2 and 3. The effluent water content failed during the second water challenge (about 105 minutes), Figure 6. As with the previous evaluations, the solids removal characteristics were good with the maximum solid content being 0.05 mg/L.

These two additional evaluations confirmed that the additive package was the cause of the increased differential pressure results and not the variation in test filters.

5.3.4.3 API/EI 1581 5th Edition Category M Element (Old Lot) with Clay-Treated 50/50 HRJ/JP-8 Blend (No Additives)

This evaluation tested the API/EI 1581 5th Edition category M element from a production lot (12/07/09) with clay-treated 50/50 HRJ/JP-8 test fuel. Since the clay treatment removes the additives, this test fuel simulates a "synthetic Jet A1" test fuel.

As shown in Figures 4 and 5, the differential pressure results were the lowest of any evaluation performed during this project, only reaching approximately 28 psid. The maximum effluent water content for the entire evaluation was only 0.7 ppm, Figure 6, and the maximum solids content was 0.050 mg/L.

5.4 Phase I Analysis and Prior Testing

Figures 4 and 5 have been updated to include one additional set of data from a prior study performed by SwRI where JP-8 (petrolum based fuel) was tested using the old lot of Velcon API/EI 5th edition M filter cartridge. The results fell within the acceptable range for the API/EI protocol, with differential pressures above the line from the clay treated blend, but below the values for the additized blends.

It is an accepted fact that the additives used to prepare JP-8 from Jet-A/Jet-A1 will increase the differential pressure witnessed during the single element test. The levels historically have been below the limits of the standard, therefore there has been limited cause for concern even at the flow rates used for this phase of the testing.

Discussions with experts in the field indicate the higher differential pressure is due to reactions between the additives and red iron oxide solids used in the test. This interaction resulted in changes in the solids used in the API 1581 3rd edition and the current version.

Regardless of the influence of the additives or the solids used, comparison of the data from the petroleum based JP-8 versus the 50/50 HRJ JP-8 blends clearly indicates an amplifying of this effect with the addition of the HRJ (see Figure 5). The increase is significant, resulting in failures of the cartridges with regard to water effluent and physical damage to the filter at 34 GPM flow. During the second phase of testing, the flow rate

used in the tests was also questioned and considered a contributing factor in the failures.

The low aromatic content is also a characteristic of Synthetic Paraffinic Kerosene (SPK). As a result a search from prior testing was performed to determine if similar results were noted. If there were similar data available, then this may link the aromatic content to the higher differential pressures.

Review of prior published data on filtration testing of SPK generated from the Fischer Tropsch method yielded little actual data on the differential pressures. Prior testing performed by the U.S. Navy (Evaluation of the Impact of Synthetic Paraffinic Kerosene and JP-8 Blend on Filters and Filter/Coalescer Performance - NAVAIRSYSCOM Report 441/09-003) was performed using a variety of filter housings and additives. Most of the tests yielded higher than anticipated differential pressures during the test. However the conclusions discounted impact of SPK on the results.

“While there are a couple of reasons why the differential pressure increased so rapidly during testing, there is no evidence to suggest that it was the use of the 50/50 blend of SPK and petroleum fuel that led to these failures.” The report led to the conclusion that the interaction between the solids and the additives were likely the cause of the higher differential pressures. The solids blend from the 3rd edition of the API/EI standard, utilized a larger particle and 100% red iron oxide particles. The influence of the additive on standard petroleum based jet fuel was significant to the point of causing very high differential pressures. So when the SPK was added to the blend, seeing a similar reaction yielded the conclusion that the SPK did not have a measurable effect. Since no data was published as part of the report, it is impossible to compare this data to the HRJ test.

The comparison did however raise a question related to the solids blend used in the testing. In the Navy report the solids were changed from a 100% red iron oxide (RIO) to a 10/90 blend of RIO and silica particles. The blend of RIO and silica is the same specified in the current (5th edition) of the API/EI filtration standard. Interviews with persons involved in the revision to the standard indicated reducing the RIO was done to reduce the interaction with certain additives. Again there is limited published data to document the interactions or agents.

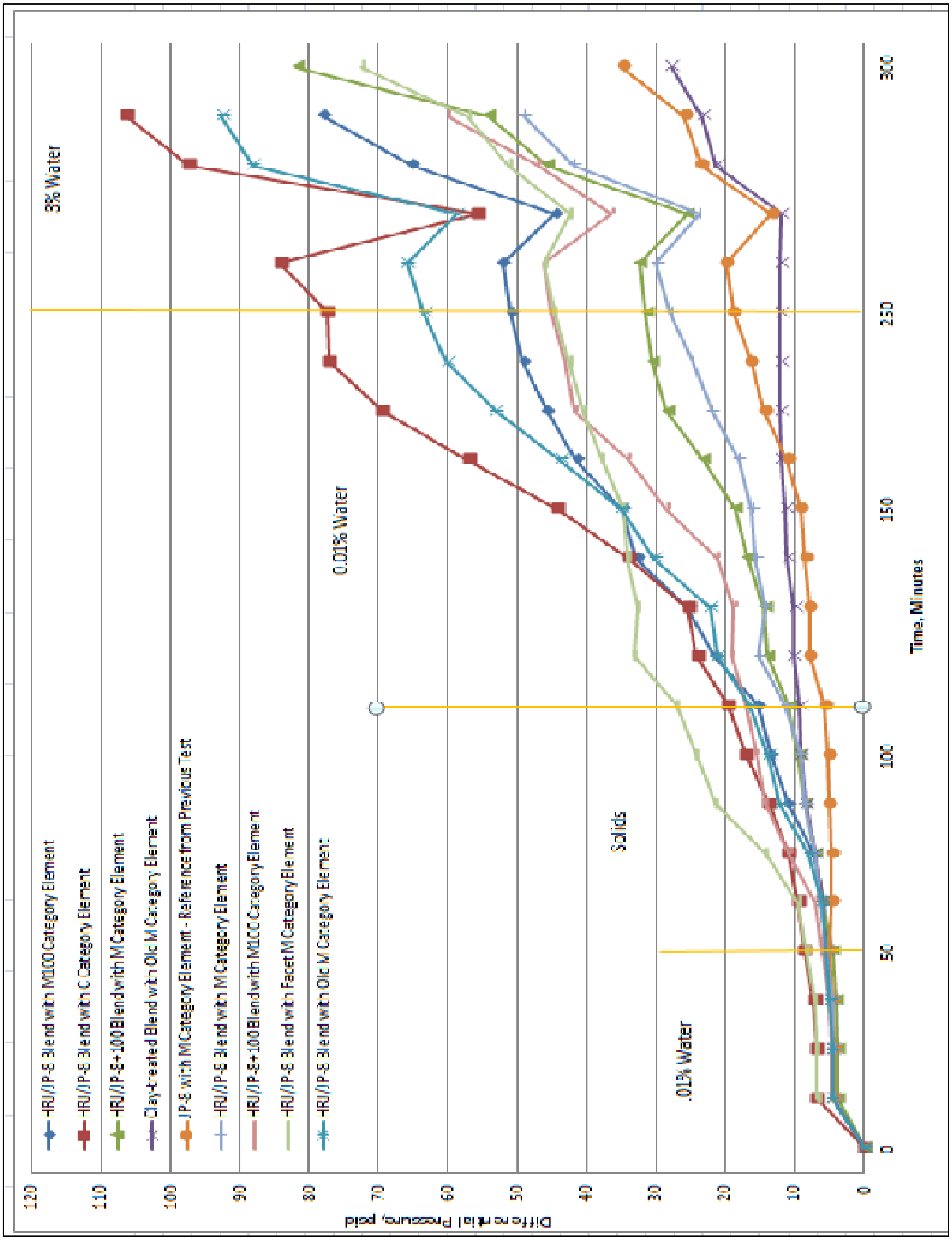

Figure 4 – Differential Pressure for API/EI 1581 5th Edition Evaluations

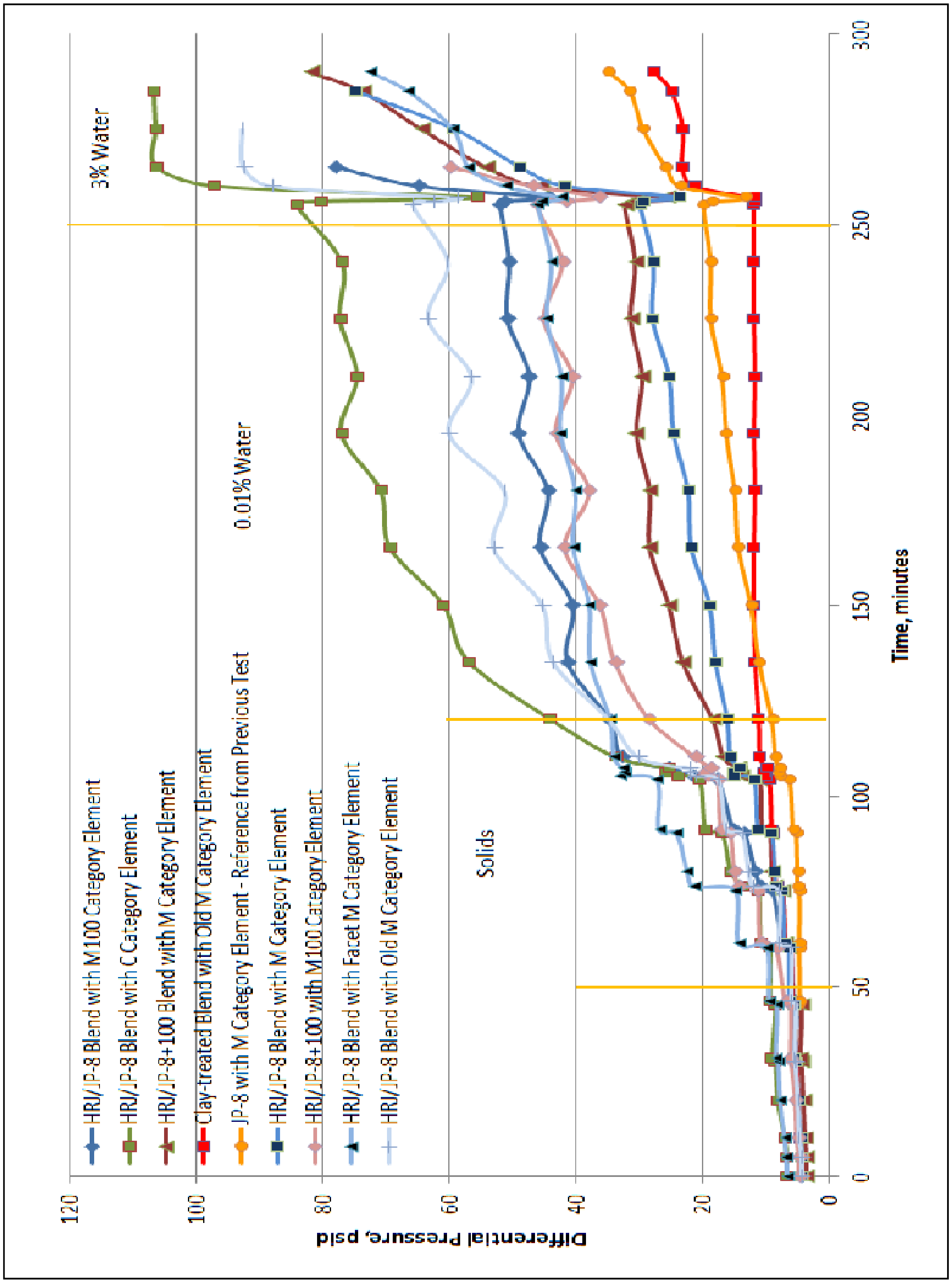

Figure 5 – Comparison of Various API/EI 1581 5th Edition Elements and Test Fuels

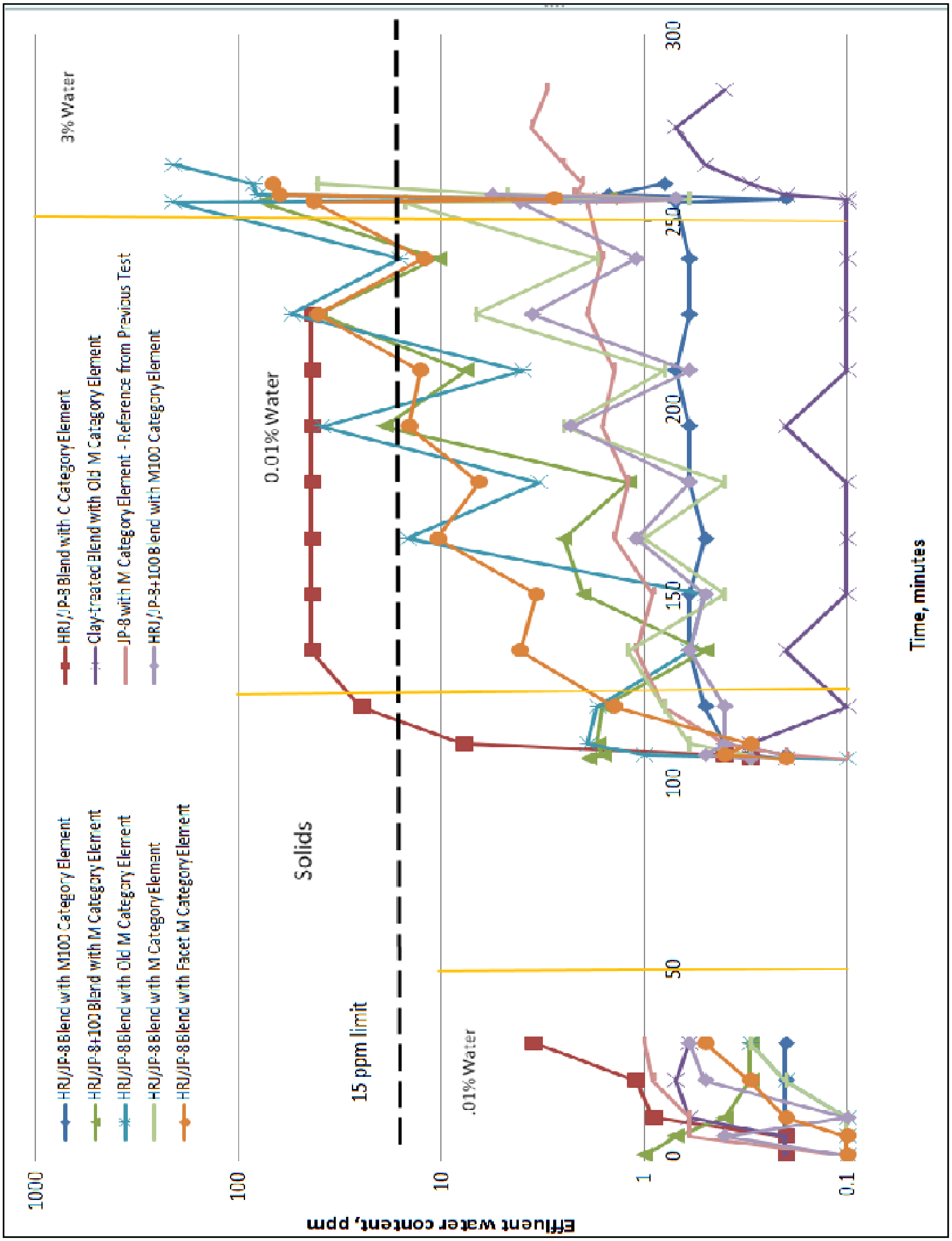

Figure 6 – Effluent Water Content Using 50/50 HRJ/JP-8 Fuel Blends

5.5 Filter/Coalescer Performance (Phase II)

The performance of these tests was to evaluate the impact of the various additives on the HRJ fuel blend. In order to effectively evaluate each additive and combination, the testing included petroleum based JP-8 fuel as well as the 50/50 blend with HRJ. The procedures began with neat fuel (i.e. no additives) and proceeded through each possible combination up to fully additized JP-8 spec fuel. There were two additional evaluations to evaluate the influence of red iron oxide on the performance of the filtration and to confirm the impacts of higher flow rates on the filter effectiveness.

For this report the tests will be discussed in pairs; petroleum jet versus HRJ blend for each of the additives and combinations. All of the tests, with the exception of tests 10 and 10H were performed at a lower flow rate than prior testing. This decision is discussed later in the report. All of the tests "passed" the criteria stated in the API/EI 1581 5th Edition standard at the lower flow rate.

5.5.1 No additives

The API/EI 5th edition single element protocol was completed using both petroleum based JP-8 and a 50/50 blend of JP-8 and HRJ. In both situations the fuel was delivered fully additized and the additives were removed prior to the tests being performed.

The addition of HRJ to the fuel did have an impact. As shown in Figure 7, the differential pressures were higher during the solids challenge with petroleum jet, however the relationship flipped during the second water challenge. At the end of the second 100 ppm water challenge, the HRJ fuel was 32% (3 psid) higher. There was no significant contamination, water or solids, in the effluent stream.

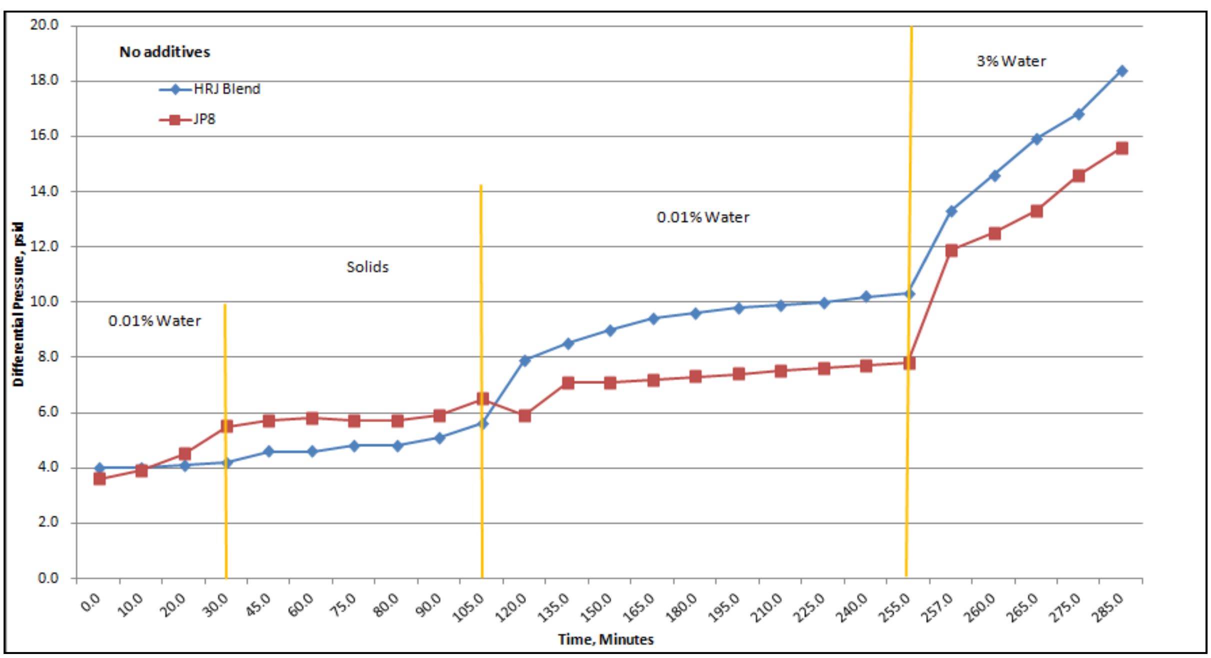

Figure 7 – Non Additized Fuel

5.5.2 Static Dissipater Additive (SDA)

The addition of the SDA additive countered the effect of adding HRJ to the fuel. The two lines overlapped almost perfectly with the HRJ blend yielding differential pressures within 3% of the petroleum fuel measurements. There was only a marginal increase in differential pressure over non-additized petroleum jet.

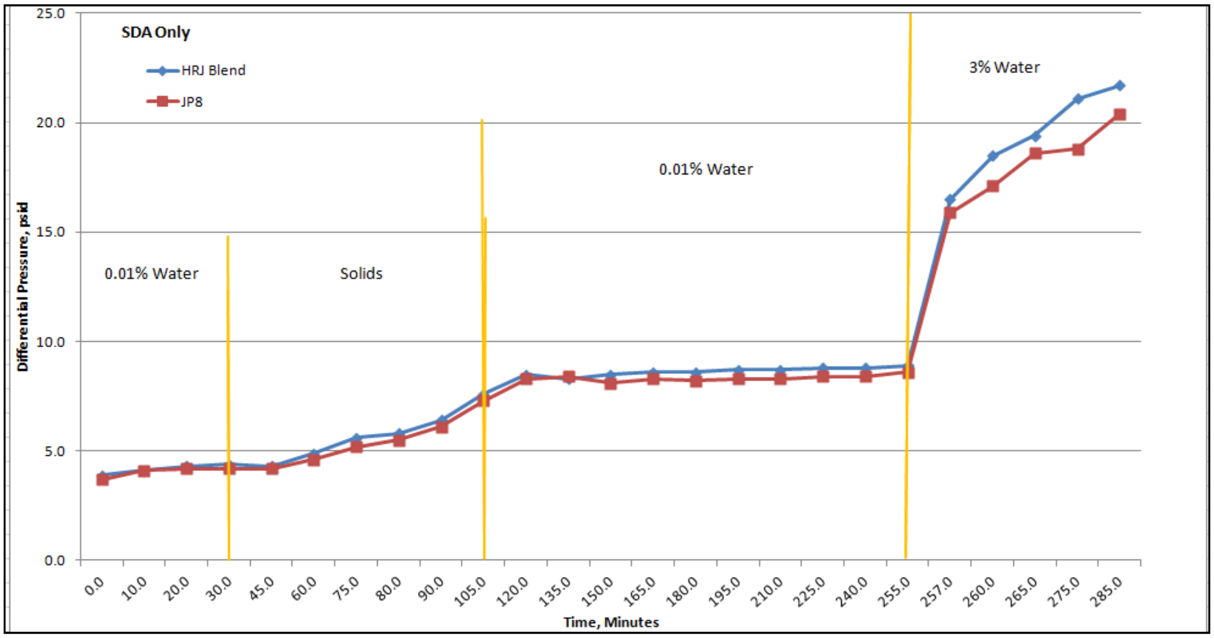

Figure 8 – SDA Additive Only

5.5.3 Fuel System Icing Inhibitor (FSII)

Similar to the previous tests, the addition of the FSII additive countered the effect of adding HRJ to the fuel. Like before, the two lines overlapped almost perfectly with the HRJ blend yielding differential pressures 4% lower that the petroleum fuel measurements.

In both the SDA and FSII tests, the differential pressures of the HRJ blend tests were lower with the additives than the results with HRJ and no additives. This indicates the additives counteract some of the effect of the HRJ on the filtration system.

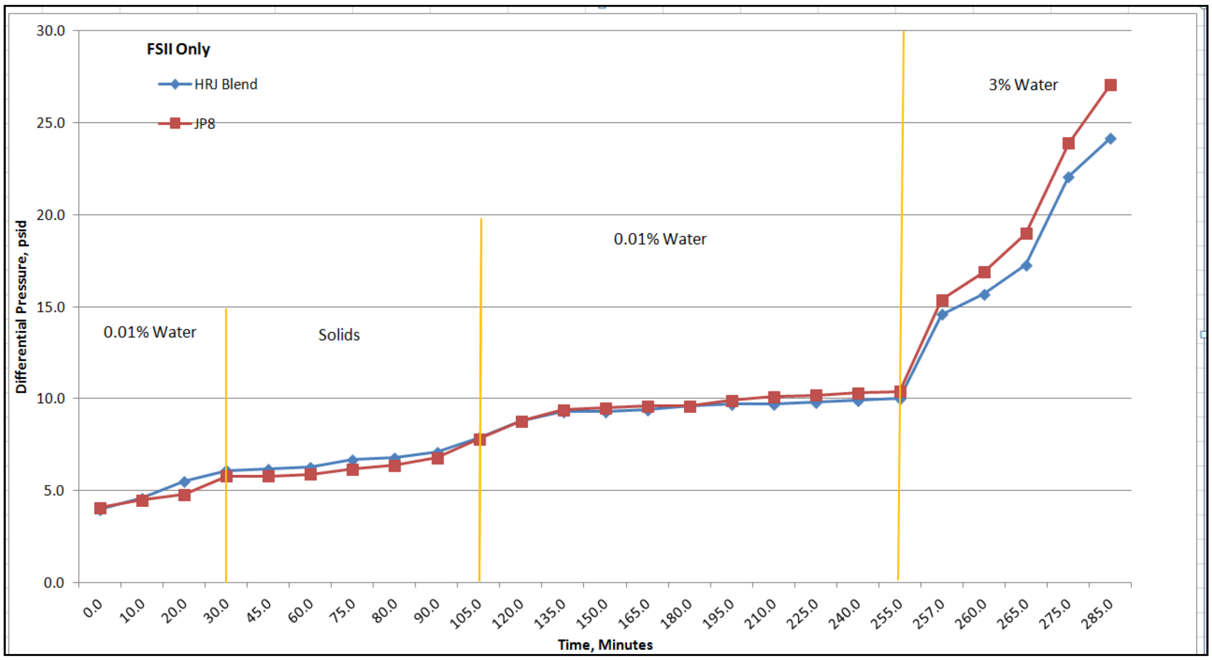

Figure 9 – FSII Additive Only

5.5.4 Corrosion Inhibitor/Lubricity Improver (CI/LI)

The addition of the CI/LI additive similarly decreased the impact of the HRJ on the differential pressures measured during the tests. The additive resulted in a 7% lower differential pressure at the end of the second water challenge. The differential pressures measured were higher than the non-additized fuel with this single additive than any other.

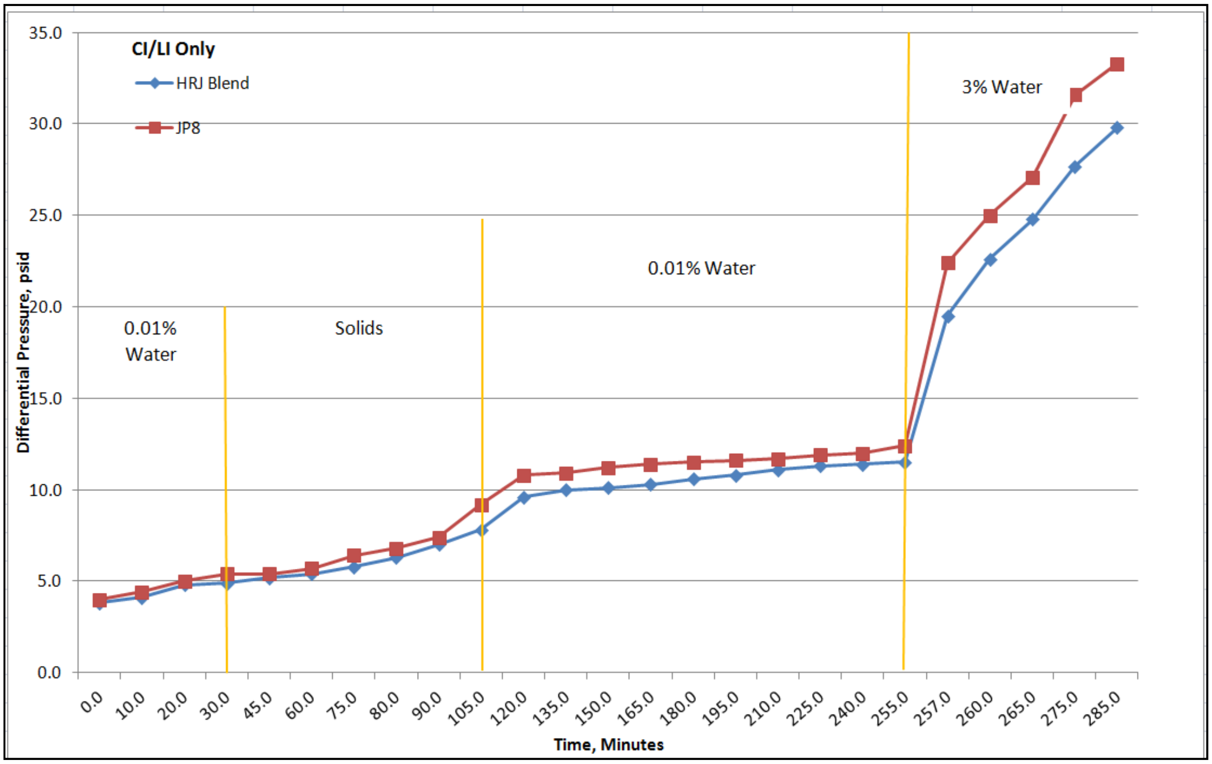

Figure 10 – CI/LI Additive Only

5.5.5 SDA – FSII

This combination of additives actually increased the effect of the HRJ being added to the blend. The differential pressure at the end of the second water challenge increased 37% (4 psid) over the same combination with petroleum JP-8 and over 80% increase over non-additized petroleum fuel. Even with the additional pressure differential, the filtration effectively removed water and solids from the effluent.

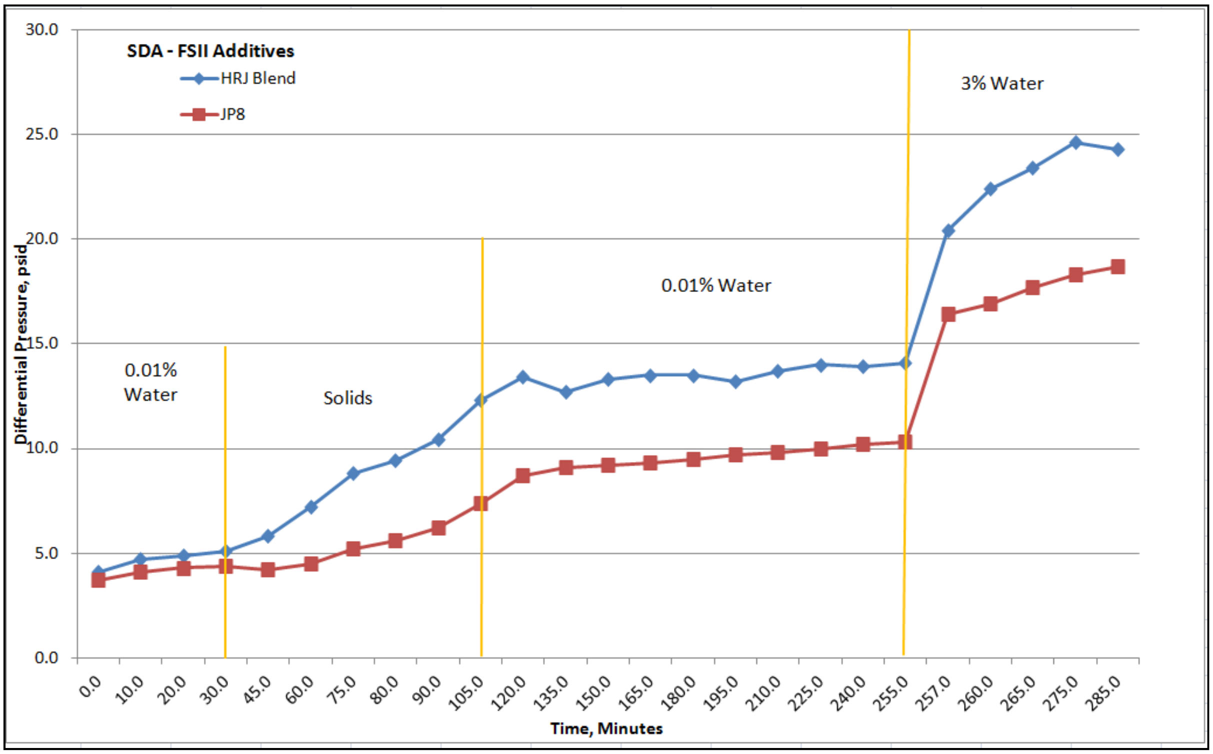

Figure 11 – SDA and FSII Additives

5.5.6 SDA – CI/LI

The combination of additives demonstrated only a marginal difference in pressure differential between petroleum jet and HRJ blended fuel. The differential pressures measured were significantly higher than non-additized fuel. (approximately 13 psid in this test versus 8 psid for petroleum jet with no additives)

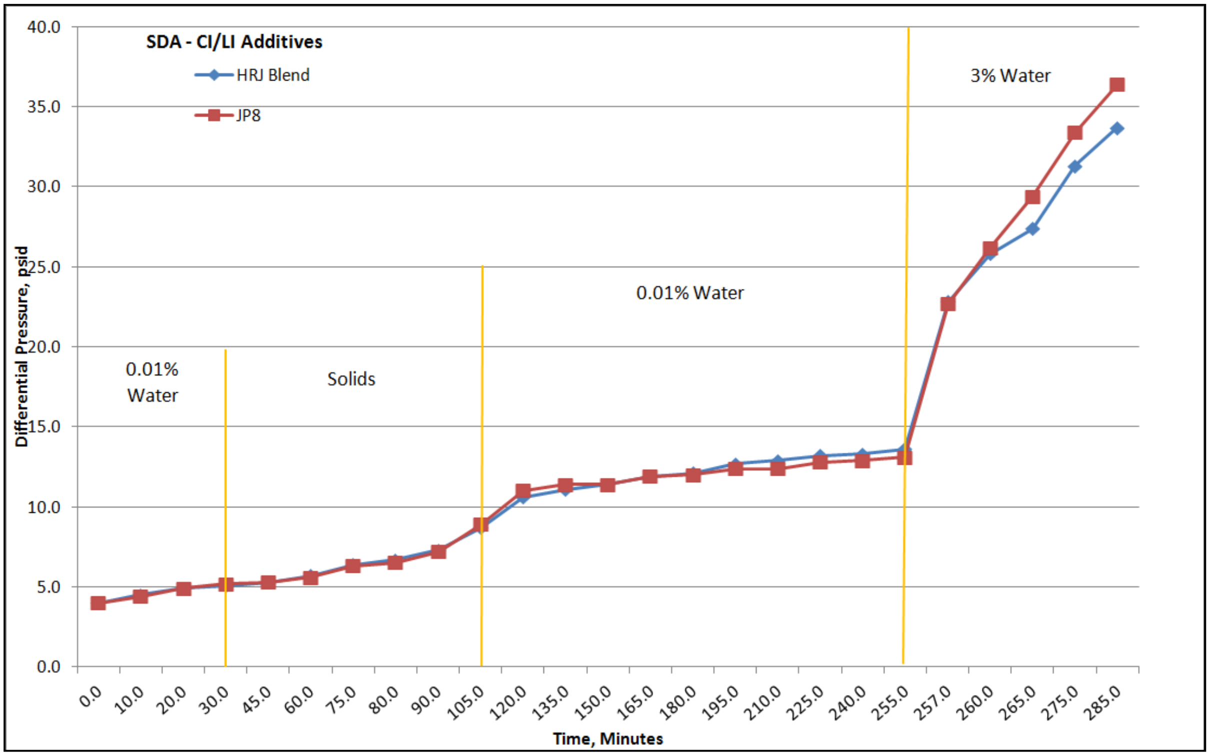

Figure 12 – SDA and CI/LI Additives

5.5.7 FSII – CI/LI

The combination of FSII and CI/LI increased both the influence of HRJ and increased the differential pressures over the non-additized fuel, however not to the same level as the SDA- FSII combination. The increase was 24% for HRJ blend over petroleum jet with the same additives and a 59% increase over non-additized petroleum jet. Again, even with the higher differential pressures, the filtration effectively removed water and solids from the fuel.

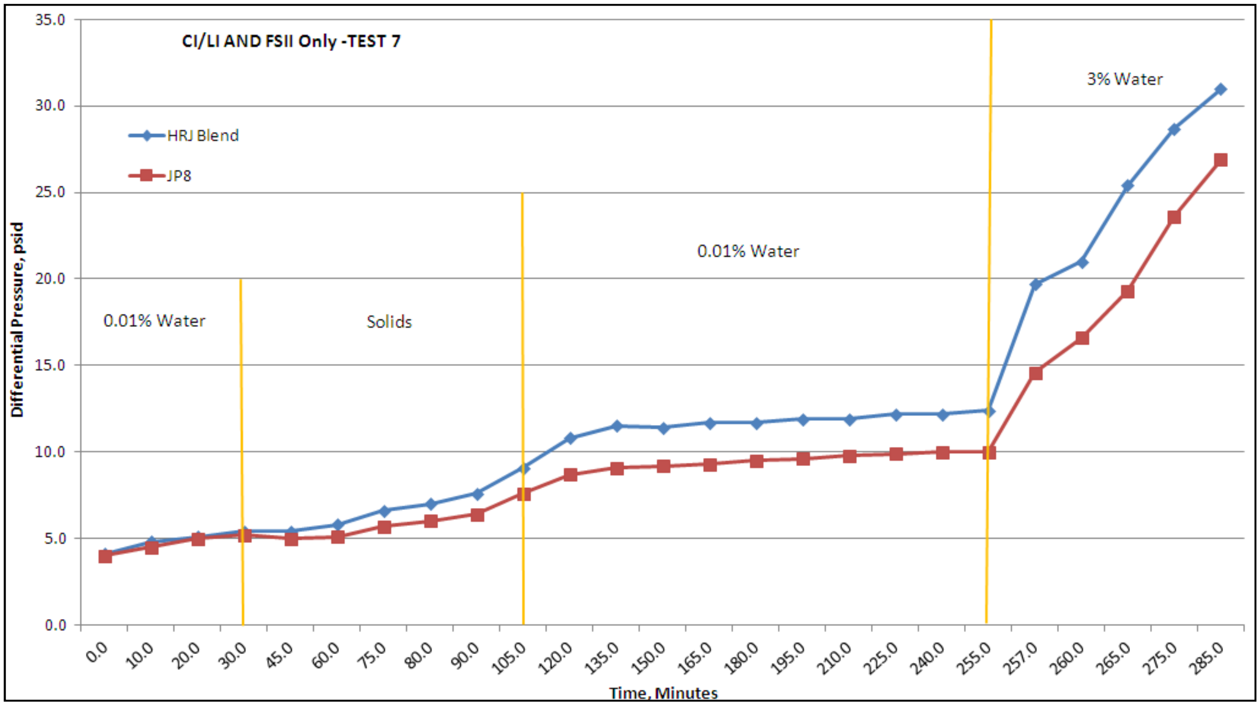

Figure 13 – FSII and CI/LI Additives

5.5.8 SDA – CI/LI – FSII (Fully additized)

As expected the fully additized fuel has a measurably high differential pressure at the end of the second water challenge as the non-additized fuels. The addition of HRJ to the blend had a smaller effect than was measured with the other combinations. However the comparison against non-additized fuels illustrates the overall impact of the additives to this type of test. The HRJ blend with additives was 171% higher than non-additized petroleum jet. The HRJ does enhance the effect of the additives with regard to differential pressures in the filtration system,

Again however, the filtration was able to effectively remove the water and solids from the fuel as measured in the effluent.

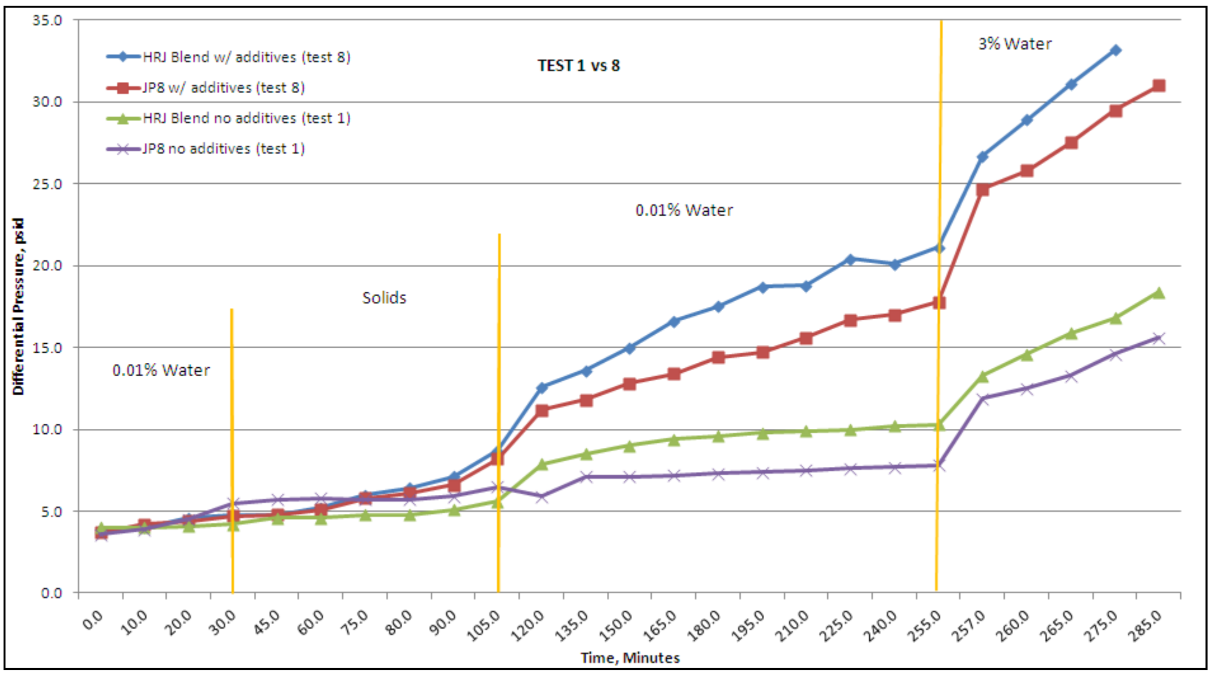

Figure 14 – Fully Additized Fuel and Non-Additized Fuel

5.5.9 Fully Additized Fuel with Changes in Procedure

This test adjusted the solids used in the test and the water concentration in the final phase of the testing. The change in solids was in response to reports from testing SPK where the red iron oxide (RIO) was blamed for the higher differential pressures with the alternative fuel blend. It is well documented that the red iron oxide content was changed between the 3rd edition of API 1581 and the 5th edition. The documentation on the justification for the change is limited.

The test used a 50%/50% blend of Arizona Test Dust A1 and A3 which is primarily silica based solids. The results were not what was expected given the references stated above. If the RIO was the source of the higher differentials, then the changes from Test 8 data should have been to decrease the change when comparing HRJ to petroleum jet. In fact, the opposite occurred. The differential pressure change increased with HRJ (approximately 53%) over JP-8 and nearly tripled that of non-additized petroleum jet at the end of the second water challenge.

The decreased water injection in the final phase of the test did not yield significant information. The increased DP due to the change in the solids resulted in higher differential pressure measurements in the final phase even though the water injected was decreased.

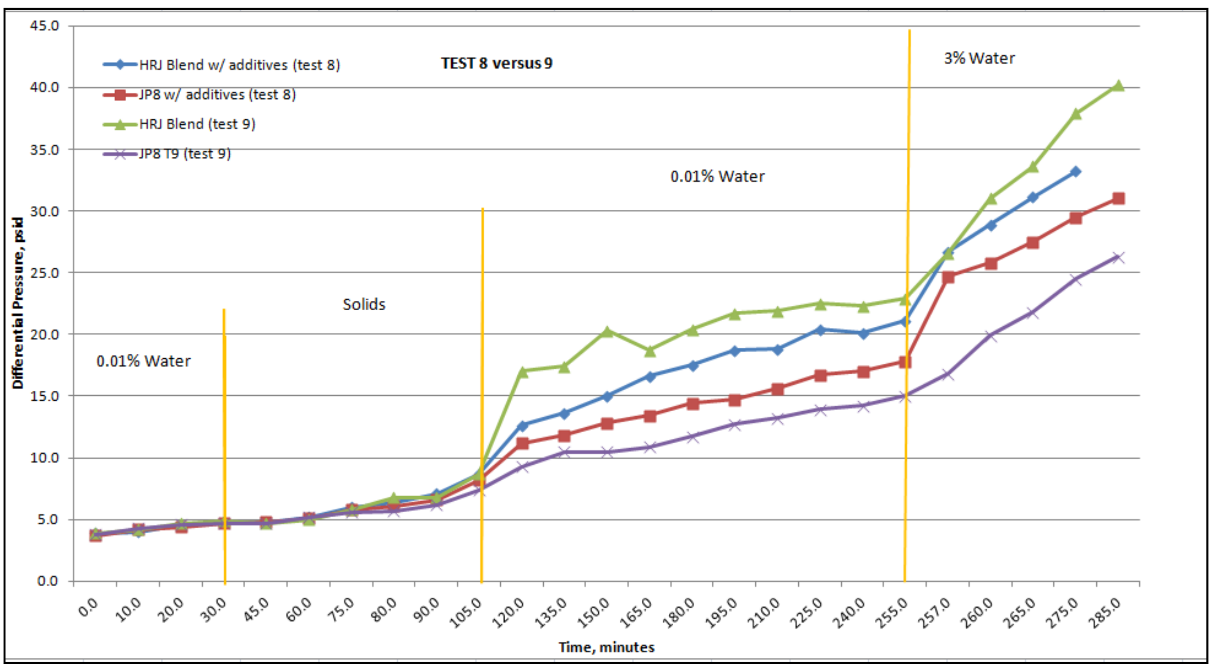

Figure 15 – Fully Additized/Modified Procedure

5.6 Phase II Analysis

5.6.1 Flow Rate Analysis

The various tests demonstrated the influence of the various additives in standard petroleum base JP-8 and the parallel data set for the HRJ blend. The results help to clarify some of the questions raised in the first phase of testing. In the preparation for the tests however a question was raised on the flow rate used in the prior tests.

Flow rate is published by most of the manufacturers in the form of a flow per inch of length for a specified diameter filter. This flow rate is different for elements certified under different standards, but overall is less than 3 gallons per inch. In the case of the Facet and Velcon API/EI 5th edition M category elements, the rate is closer to 2.6 gallons per inch. This being said, the manufacturers do not publish a maximum flow rate for a specific size of element. The typical flow certification is for a complete filter/separator which includes the coalescing element, separator element and the vessel.

This creates a challenge when performing tests such as those performed in the first phase of this study as the flow rates for the three classes of elements are different. It is complicated further by the lack of published data related to the "length" to be used in determining the maximum flow. In this situation, the elements used are 6" diameter x 14" overall length. This overall length includes end caps on both ends, which reduce the actual element length. The manufacturers do not publish the "effective length", so Pond interviewed the suppliers to obtain the effective length of the elements.

The flow rate used in the Phase I testing was 34 gallons per minute, which when combined with an effective length of 11.7" yields a flow per inch around 2.9 gallons. This flow rate exceeds the recommended maximum for a 5th edition M element. Interviews with the suppliers yielded that maximum flow is established based upon performance testing of the various elements.

The flow rate is impacts the filter performance in two ways: first, the actual amount of water and solids is higher with higher flows because they are introduced as percentages of total flow and secondly, the higher flow will naturally increase the differential pressure even with clean fuel. By testing at a higher flow rate, the pass/fail criterion of the first phase of tests cannot be considered. What can be considered is the relative performance of the elements with petroleum JP-8 and the HRJ blends.

In the second phase of tests, the flow rate of 25.9 gallons per minute was recommended by the filter supplier and testing agent, Facet. This rate is slightly below the maximum flow per inch of the elements used for the Phase II tests. The result of this adjustment is evident in the lower differential pressures measured during the test and the passing results in each and every test. The focus of the analysis therefore is on the impact of HRJ with each of the additives as opposed to filtration failures.

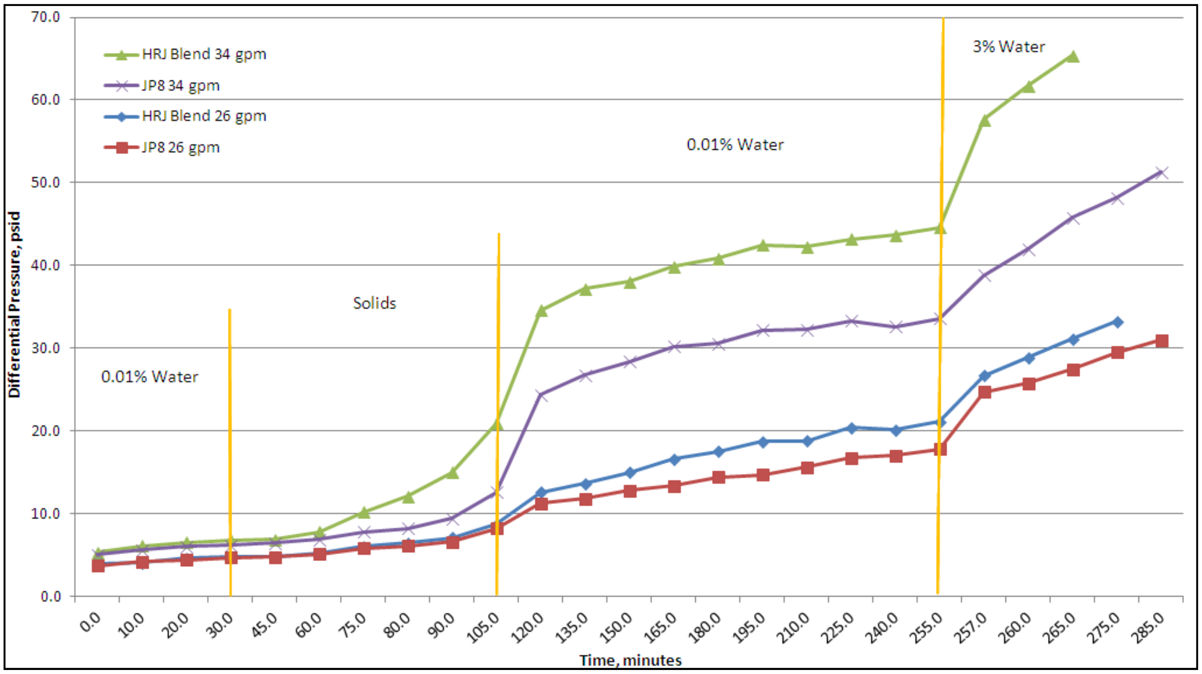

Figure16 – Flow Rate Comparison

5.6.2 Additive Interaction Analysis

Review of the various tests indicates which additives cause the largest changes in differential pressure with standard petroleum jet. The general increases in differential pressure at the end of the second 0.01% water challenge was used since this is more likely to occur than a 3% contamination. Table 3 recaps the effect of the various additives on petroleum jet and the HRJ blended fuel.

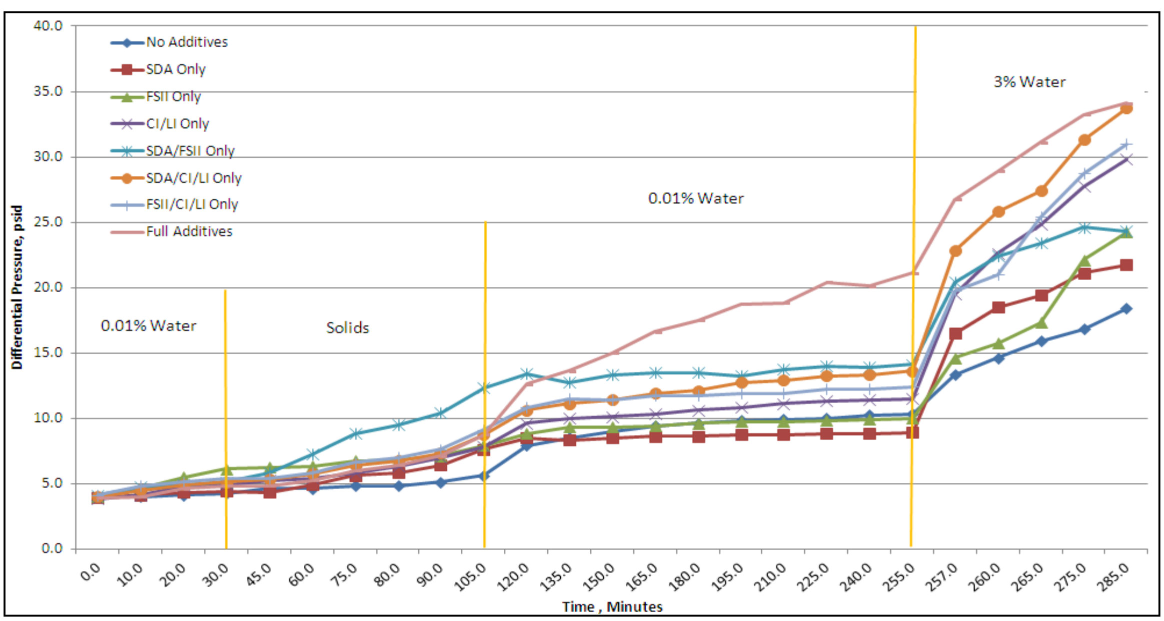

Figure 17 – HRJ Blend – Effect of Additives

Table 3

	Petroleum JP-8	50% HRJ/50% JP-8*
Neat fuel (no additives)	--	--
SDA only	10%	-14%
FSII only	33%	-3%
CI/LI only	59%	12%
SDA and FSII	32%	37%
SDA and CI/LI	68%	32%
CI/LI and FSII	28%	20%
SDA, CI/LI and FSII	128%	105%

* JP-8 is petroleum based fuel

The additive that had the largest individual influence with both fuels was the corrosion inhibitor/lubricity improver (CI/LI). It was interesting to note that when SDA and FSII were added to the HRJ blend, the differential pressures at the end of the second water challenge were actually lower than the non-additized fuel.

When considering the combinations of additives, the combination of SDA and CI/LI had the largest impact on petroleum fuel, but the effect on the HRJ blended fuel was the least of the paired additive blends. The additives clearly interact differently with the HRJ blended fuel.

When considering the full additive package, the actual increase for both the petroleum and HRJ blends was 10 and 10.8 psid when compared to the non-additized fuels. So the actual increase created by the additives was consistent.

5.6.3 HRJ Interaction Analysis

When considering the influence of HRJ on the differential pressures, the results are somewhat mixed. When comparing non-additized fuel tests, HRJ caused a 32% increase in differential pressure over petroleum jet. The initial assumption would be that this would be consistent. However the individual additives actually counteracted the influence of the HRJ (for example the effect of CI/LI was lower with the HRJ in the blend.

The additional differential pressure in the fully additized fuel was smaller than non-additized when looking at the percentage only. The actual changes in the differential pressures were 2.5 psid for non additized fuel and 3.3 psid for fully additized fuel. This net increase is measurable, but clearly manageable.

Table 4

	HRJ vs Pet JP-8	HRJ vs Pet Jet No additives
Neat fuel (no additives)	32%	--
SDA only	3%	14%
FSII only	-4%	28%
CI/LI only	-7%	47%
SDA and FSII	37%	81%
SDA and CI/LI	4%	74%
CI/LI and FSII	24%	59%
SDA, CI/LI and FSII	19%	171%

The final column of percentage changes shown in Table 4 is a comparison of the measured differential pressures with the additized fuel with HRJ to a baseline using non-additized petroleum jet fuel. This column applies if you consider HRJ as another additive (i.e. a comparison of HRJ/JP-8 versus Jet-A1). There is clearly a difference in measured pressures. It must be noted that at the flow rates used, even with the higher differential pressures, the elements passed the API/EI 1581 5th edition criteria.

5.6.4 Additional Test Data

Also included in the appendices of this report are the measured water and solids in the effluent from each of the tests outlined above. The measured values were all below the acceptable limits. No water was measured downstream of the filtration through the second water challenge. Even during the 3% challenge, the water levels noted using the Aqua-Glo procedures were very low. There were no significant solids measured downstream of the filtration.

5.6.5 Alternate Procedure Test

Test #9 made two changes to the standard procedure. The solids used in the second phase of the test were changed to eliminate the red iron oxide, and to include smaller particles of the silica. Based upon data reviewed during the first phase of testing, this change was expected to decrease the effect of the solids on differential pressure. The data ran counter to this assumption. The interaction of HRJ with the RIO was not validated when comparing the results of this test to the standard test.

5.6.6 Additional Flow Rate Test

One additional test was performed at the higher flow rate used during the Phase I testing to validate the results of the test and ensure the various data sets could be included together. The results of the tests with higher flow rate matched the differential pressures recorded during the Phase I tests. The effluent water and solids passed however even with the higher differential pressures. It is assumed that this is due to a different separator being used in this series of tests (SwRI used a Velcon element).

6.0 Conclusions and Recommendations

6.1 General

The goal and intent of this study was to provide data to support certification of Hydro-Treated Renewable Jet (HRJ) fuel as compatible for use with the existing U.S. Air Force (USAF) fuels infrastructure. The results of the testing indicate the introduction of HRJ as a blending agent with petroleum JP-8 does have an effect on the filtration systems presently in use. However there is no indication that the existing filtration systems will not effectively remove water and solids from the fuel.

HRJ appears to amplify the existing interactions between the additives in JP-8 and the combination of water and solids used in the API/EI 1581 5th edition single element testing protocol. This results in higher differential pressures at the same level of contamination in the fuel. At most this will equate to replacement of the filters earlier when HRJ is present in the fuel system.

The typical operational limit on a filter separator vessel is 15 psid before the operator replaces the elements. At the 15 psid levels none of the tests indicated water contamination levels beyond the 15ppm limit in either the Phase I or Phase II tests. The risk therefore of issuing water into an aircraft is extremely small.

6.2 Operational Impacts

The impact of the introduction of HRJ into an operational fuel system may be significant. If we assume a system that is operating within acceptable limits related to water removal, solids removal, differential pressures, etc., the introduction of HRJ could create an increase in the differential pressures on all phases of the filtration system. The interaction between the HRJ with some water in the delivery vehicle (truck or pipeline) hitting a dirty filter, may result in an increase above the 20 psid limit on the inbound filter separator when it previously had been well below the limit. One of two things will then occur: either the operator will stop the receipt to change filters (assuming they are on site) or the increase will go unnoticed and excess water may pass through the filter into the storage system.

If maintenance is proper, the risk of water going from the tanks into an aircraft reduces as the fuel passes through the system. However the risk of differential pressure increases at any of the filters is significant. Operators will therefore need to be aware of the potential hazard and be prepared to adjust as needed to maintain readiness.

As stated above the result is that filters may be replaced more frequently. Given the interactions described, filters will reach the 20 psid sooner than current experience when HRJ blended fuels are introduced.

6.3 Impact of +100 additives

There was no significant effect using either the M100 elements or the +100 additive. After the water coalescing effectiveness tests, there was a thought that the use of M100 elements may provide improved performance with HRJ. This theory was negated during

the single element testing where the M100 elements were tested with +100 additive and without yielding similar results as the standard M category elements.

6.4 Other concerns beyond the scope of this study - Conductivity

The conductivity of the HRJ blended fuels with the specified levels of additive (Stadis 450) were well below the values typically measured with petroleum jet fuels in the first phase of testing. This is not believed to be an impact on this evaluation, however it may have impacts in the overall certification process. Interviews with DLA-Energy personnel and the USAF indicate that this factor is being investigated by others. There is no clear indication the drop in conductivity is a factor in this portion of the investigation.

6.5 Other concerns beyond the scope of this study – Flow Rate

Flow rate can impact the performance of the filtration system. Higher flow rates result in higher differential pressures, but also can create situations where water and solids removal performance can be affected. The standard flow rate for API 1581 3rd edition filters is higher than that of API/EI 5th edition M filters.

The current practice when replacing elements in existing filtration is to use 5th edition M elements. When installing these elements in a 3rd edition filtration system, the system performance cannot be expected to satisfy the 5th edition performance standard. There is a risk that the higher flow rate experienced by the new elements may exceed the manufacturer's recommended maximum flow rate. This can impact the water and solids removal performance of the new element.

The high flow rate data from this report indicates that water removal performance specifically can be affected especially when the differential pressures exceed the operating range (15 to 20 psid). While this can be considered a risk controlled by operational procedures, Pond has witnessed DoD fueling facilities where the systems as found were beyond 15 psid at rated flow for a variety of reasons.

The risk is compounded by the primary finding in this report that when HRJ is introduced into a facility the differential pressure will increase over the measured values with petroleum JP-8. A combination of events could result in failure of the system to effectively remove water from the fuel.

6.6 Recommendations

- Develop and Engineering Technical Letter (ETL) for the introduction of HRJ into fuel systems that reinforces the importance of monitoring differential pressures in filtration systems because the introduction of HRJ will result in an increase in DP through "dirty" filters. The ETL needs to include additional direction when 5th edition M elements are installed in older filtration systems.

- Review the standard process for upgrading filtration elements in older vessels to ensure the rated flow is not exceeded for the new elements as this can result in reduced performance of the filtration system as opposed to the anticipated improvement.

Appendix A

Acronyms/Abbreviations

AFCESA	Air Force Civil Engineer Support Agency
AFPA	Air Force Petroleum Agency
API	American Petroleum Institute
ASTM	ASTM International (formerly American Society for Testing and Materials)
CI/LI	Corrosion Inhibitor/Lubricity Improver
DLA	Defense Logistics Agency
DoD	Department of Defense
DP	Differential Pressure
EI	Energy Institute
FSII	Fuel System Icing Inhibitor
HRJ	Hydro-Treated Renewable Jet
JP-8	Jet Propellant 8
MSEP	Microseparometer rating
psid	pounds per square inch differential
SDA	Static Dissipater Additive
SPK	Synthetic Petroleum Kerosene
UFC	Unified Facilities Criteria
USAF	United States Air Force
pS/m	pico Siemens per meter is a measure of fuel conductivity

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Appendix B

Original AFCESA Statement of Work APPENDIX A

HRJ Filtration Sustainment Engineering
Performance Work Statement

Task: Perform a sustainment engineering evaluation of the material compatibility and impact on water/dirt removal performance of an additized Hydro-treated Renewable Jet, (HRJ) and M-Category fuel blend on a API/IP 3rd Edition, 5th edition M, and 5th edition M100 filter/coalescer.

<u>1.0 Objective</u>

The objectives of this sustainment engineering program are to:

1.1 Evaluate the material compatibility of an additized HRJ fuel and standard M-Category fuel blend on a clean, new API/IP 1581 3rd and 5th edition filter/coalescer.

1.2 Evaluate the impact on the water coalescing effectiveness of single clean, new and used API/IP 1581 3rd and 5th edition filter/coalescer element by an additized HRJ fuel and standard M-Category fuel blend.

1.3 Evaluate the impact of an additized HRJ fuel and standard M-Category fuel blend on a clean, new API/IP 1581 3rd and 5th edition M/M100 filter/coalescer to determine if it alters the solids/water removal performance.

<u>2.0 Background</u>

2.1 In the logistics of delivering fuel from the point of production to the aircraft, the Department of Defense (DoD) and Air Force have filtration systems in place. These systems rely upon physical or surface interaction to remove dirt and water, which may collect in the fuel during transport. The majority of in-use filtration systems are designed to the following standard:

2.2 API/IP 1581 – The American Petroleum Institute (US) and Energy Institute (EI) 1581 standard is the world's commercial specification for Aerospace filtration and coalescers. There have been several revisions to this specification. API/IP 5th edition designs were introduced in 2002, and represent the newest available technology, and include both commercial (C) and military (M) classifications.

2.3 The API/IP 1581 5th Edition, "M" class design takes into account the standard JP-8 additives (fuel system icing inhibitor (FSII), static dissipater additive (SDA), and corrosion inhibitor/lubricity improver (CI/LI).

2.4 The API/IP 1581 5th Edition "M100" class design takes into account the standard JP-8+100 additives (standard JP-8 additives plus Spec-Aid® 8Q462).

2.5 The API/IP 1581 3rd Edition "B" and "C" class design takes into account the static dissipater and corrosion inhibitor/lubricity improver additives.

2.6 A M-Category fuel is defined as a fully petroleum-derived Jet-A/Jet A-1 with the standard M-category additives at rates specified by specification or test protocol (FSII, SDA, CI/LI) or a conventional, fully petroleum-derived JP-5/8 which has been purchased as JP-5/8.

2.7 A HRJ fuel is defined as a fully bio-derived synthetic paraffinic kerosene without the standard M-category additives (FSII, SDA, CI/LI)

2.8 An additized HRJ fuel is defined as a fully bio-derived synthetic paraffinic kerosene with the standard M-category additives at rates specified by specification or test protocol (FSII, SDA, CI/LI)

2.9 Current Air Force fixed fuels infrastructure and mobile refueling filtration standard is API/IP 1581 5th edition. There are also earlier API 3rd Edition filtration systems installed throughout the Air Force mobile refueling fleet and fuels infrastructure. As the Defense Logistics Agency (DLA) Energy and the DoD pursue procurement and introduction of HRJ blends into the DoD bulk fuels supply chain, the impact on filtration systems meeting API/IP 1581 5th/3rd editions must be determined to influence decisions on the type of filtration systems purchased.

3.0 Scope

3.1 Modified API 1581 5th edition protocols will be used. The program will be broken into three evaluation phases:

3.2 Material Compatibility Evaluation Phase: Evaluation containers as described in API 1581 5th Edition, Para 4.6.2 will be utilized for determining material compatibility on API/IP 1581 3rd and 5th Edition M/M100 filter/coalescer elements in accordance with the protocols specified.

3.3 Single Element Coalescer Effectiveness Evaluation Phase: Rig evaluation will be used for determining the impact on the water coalescing capability of single coalescer element using both new elements and elements from the Material Compatibility Evaluation Phase. Evaluation will be by USAF approved protocol developed by contractor based on single element coalescer effectiveness tester configuration.

3.4 New Single Element Evaluation Phase: Rig evaluation will be utilized for determining filtration issues with API/IP 1581 3rd and 5th Edition M and M100 filter/coalescer elements in accordance with the protocols specified. Single element test evaluation will utilize filter/coalescer elements and corresponding separators designed for the evaluation rig.

3.5 Filter/coalescer element sizes that will be utilized in all evaluation phases will be determined by the Air Force based on service certification requirements. Single element evaluation will utilize filter/coalescer elements and corresponding separators as required.

3.6 Single element water coalescing effectiveness and single element performance test evaluations are a pass/no-pass evaluation. Material compatibility evaluations will be reported IAW modified protocol from API/IP 1581 5th Edition, Para 4.6.2. Prior to execution of all tasks, a fully documented detailed protocol shall be prepared for approval by the Air Force. Any deviation from that protocol shall be fully documented and justified for Air Force approval prior to beginning of evaluation. Air Force may reject any proposed deviation.

3.7 Evaluation and analysis shall be completed IAW evaluation protocols for using various fuel types to include a M-Category fuel, a HRJ fuel (100 % neat), an additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel), and an additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel) with Spec-Aid® 8Q462 thermal stability additive at specified concentration.

3.8 All fuel types used during testing will be clay treated after each evaluation and then re-additized as required IAW testing protocol prescribed.

4.0 Description

4.1 Contractor shall be using Air Force provided HRJ fuel:

4.2 Evaluate the material compatibility of prescribed fuel types on clean, new API/IP 3rd, 5th edition M, and 5th edition M100 filter/coalescers. Material compatibility evaluation and analysis shall be completed IAW modified API 1581 5th Edition, Para 4.6.2 evaluation protocol. Evaluation protocol shall be modified to only perform the

compatibility (soak) test on the various fuel types as specified for each filter/coalescer. All timeframes and laboratory evaluations from API 1581 5th Edition, Para 4.6.2 will otherwise be complied with.

4.2.1 API/IP 3rd Edition
4.2.1.2 M-Category fuel
4.2.1.3 Additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel)

4.2.2 API/IP 5th Edition M
4.2.2.1 M-Category fuel
4.2.2.2 Additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel)

4.2.3 API/IP 5th Edition M100
4.2.3.1 M-Category fuel with Spec-Aid® 8Q462 thermal stability additive at specified concentration
4.2.3.2 Additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel) with Spec-Aid® 8Q462 thermal stability additive at specified concentration.

4.3 Evaluate the water coalescing effectiveness of a single API/IP 3rd, 5th edition M, and 5th edition M100 filter/coalescers element using both new elements and elements from the Material Compatibility Evaluation Phase to determine various fuel types impact. Evaluation will be by USAF approved protocol developed by contractor based on single element coalesce tester configuration.

4.3.1 API/IP 3rd Edition
4.3.1.1 Additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel)

4.3.2 API/IP 5th Edition M
4.3.2.1 Additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel)

4.3.3 API/IP 5th Edition M100
4.3.1.1 Additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel) with Spec-Aid® 8Q462 thermal stability additive at specified concentration.

4.4 Evaluate the impact of various fuel types on clean, new API/IP 3rd, 5th edition M, and 5th edition M100 filter/coalescers to determine if they alter the solids/water removal performance of the specified filter/coalescer. A single element evaluation will be performed on each filter/coalescer type using a modified API/IP 5th Edition single element test protocol for filter/coalescers as documented in API 1581 5th Edition, Para 4.3. Evaluation protocol shall be modified to substitute prescribed fuel types for each filter/coalescer for the "test fuel" specified. All other procedures, processes, and requirements will be complied with.

4.4.1 API/IP 3rd Edition
4.4.1.1 Additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel)

4.4.2 API/IP 5th Edition M
4.4.2.1 Additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel)

4.4.3 API/IP 5th Edition M100
4.4.3.1 Additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel) with Spec-Aid® 8Q462 thermal stability additive at specified concentration.

5.0 Period of Testing

5.1 Evaluation of the material compatibility and impact on water/dirt removal performance of an additized Hydro-treated Renewable Jet, (HRJ) and M-Category fuel blend on a API/IP 3rd Edition, 5th edition M, and 5th edition M100 filter/coalescer shall be completed as specified.

6.0 Deliverables for F/S Testing

6.1 The contractor shall provide informal monthly teleconference updates and bi-monthly progress reports.

6.2 The contractor shall prepare the following reviews/presentations for Air Force review and comment:

6.2.1 A kick-off review wherein the contractor shall review all testing assumptions, protocols and procedures that will be used during this program

6.2.2 A mid-program review presentation to be given at a time and location agreed to by the contractor and Air Force.

6.2.3 A final report with recommendations shall be prepared and provided to the Air Force

6.2.4 The final report shall present all data and shall make recommendations for each filter/coalesce type regarding its suitability for use with an additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel) with and without the Spec-Aid® 8Q462 thermal stability additive as required.

6.2.5 The contractor shall also prepare a presentation to accompany the final report covering the results of this work.

6.2.6 A public release version of the final report and final presentation shall be prepared and provided to the Air Force.

APPENDIX D (Added 13 Jan 11)

HRJ Filtration Sustainment Engineering
Performance Work Statement

Task: Perform a follow-on sustainment engineering evaluation of the impact on water/dirt removal performance of Hydro-treated Renewable Jet, (HRJ) and M-Category fuel blend on a API/IP 5th edition M filter/coalescer when the fuel contains various fuel additives.

<u>1.0 Objective</u>

The objectives of this sustainment engineering program are to:

1.1 Evaluate the impact on the water coalescing effectiveness of single clean, new API/IP 1581 5th edition filter/coalescer element by standard M-Category fuel and a 50/50 blend of HRJ and M-Category fuel that contain various military additives.

<u>2.0 Background</u>

2.1 In the logistics of delivering fuel from the point of production to the aircraft, the Department of Defense (DoD) and Air Force have filtration systems in place. These systems rely upon physical or surface interaction to remove dirt and water, which may collect in the fuel during transport. The majority of in-use filtration systems are designed to the following standard:

2.2 API/IP 1581 – The American Petroleum Institute (US) and Institute of Petroleum (IP) 1581 standard is the world's commercial specification for Aerospace filtration and coalescers. There have been several revisions to this specification. API/IP 5th edition designs were introduced in 2002, and represent the newest available technology, and include both commercial (C) and military (M) classifications.

2.3 The API/IP 1581 5th Edition, "M" class design takes into account the standard JP-8 additives (fuel system icing inhibitor(FSII), static dissipater additive(SDA), and corrosion inhibitor/lubricity improverCI/LI)).

2.4 A M-Category fuel is defined as a fully petroleum-derived Jet-A/Jet A-1 with the standard M-category additives at rates specified by specification or test protocol (FSII, SDA, CI/LI) or a conventional, fully petroleum-derived JP-5/8 which has been purchased as JP-5/8.

2.5 A HRJ fuel is defined as a fully bio-derived synthetic paraffinic kerosene without the standard M-category additives (FSII, SDA, CI/LI)

2.6 An additized HRJ fuel is defined as a fully bio-derived synthetic paraffinic kerosene with the standard M-category additives at rates specified by specification or test protocol (FSII, SDA, CI/LI)

2.7 Current Air Force fixed fuels infrastructure and mobile refueling filtration standard is API/IP 1581 5th edition. As the Defense Logistics Agency - Energy (DLA Energy) and the DoD pursue procurement and introduction of HRJ blends into the DoD bulk fuels supply chain, the impact on filtration systems meeting API/IP 1581 5$^{th/}$editions must be determined to influence decisions on the type of filtration systems purchased.

<u>3.0 Scope</u>

3.1 All work to be completed at a filter manufacturing facility.

3.2 Modified API 1581 5th edition protocols will be used (modification is due to use of synthetic fuel rather than actual testing process).

3.3 Single Element Coalescer Effectiveness Evaluation Phase: Rig evaluation will be used for determining the impact on the water coalescing capability of single coalescer element using new elements. Evaluation will be by USAF approved protocol developed by contractor based on single element coalescer effectiveness tester configuration. This evaluation will be conducted on unadditized JP-8 using a matrix of SDA, FSII and CI/LI fuel additives and on a 50/50 blend of Neat HRJ and unadditized JP-8 using a matrix of SDA, FSII and CI/LI fuel additives.

3.4 Filter/coalescer element sizes that will be utilized in all evaluation phases will be determined by the Air Force based on service certification requirements. Single element evaluation will utilize filter/coalescer elements and corresponding separators as required.

3.5 Single element water coalescing effectiveness and single element performance test evaluations are a pass/no-pass evaluation. Prior to execution of all tasks, a fully documented detailed protocol shall be prepared for approval by the Air Force. Any deviation from that protocol shall be fully documented and justified for Air Force approval prior to beginning of evaluation. Air Force may reject any proposed deviation.

3.6 Evaluation and analysis shall be completed IAW evaluation protocols for using various fuel types to include a M-Category fuel, and additized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel) at specified concentration.

3.7 All fuel types used during testing will be clay treated after each evaluation and then re-additized as required IAW testing protocol prescribed.

3.8 One-gallon samples will be obtained and submitted to the Aerospace Fuels Laboratory at Wright-Patterson AFB when the fuel is received and prior to each evaluation after each additization. An additional one-gallon sample will be obtained following each evaluation prior to clay treatment. The post evaluation sample will be retained at the testing site and shipped to Wright Patterson only if requested. All samples will be identified by test number and whether they were pre or post evaluation. Sample results will be made available to the contractor.

4.0 Description

4.1 Contractor shall use Air Force provided fuels unless otherwise authorized by the Air Force:

4.2 Evaluate the water coalescing effectiveness of a single API/IP 5th edition M filter/coalescer element using a new element to determine various fuel types impact. A single element evaluation will be performed using a modified API/IP 5th Edition single element test protocol for filter/coalescers as documented in API 1581 5th Edition, Para 4.3. Evaluation protocol shall be modified to substitute prescribed fuel types for the "test fuel" specified. All other procedures, processes, and requirements will be complied with.

4.2.1 API/IP 5th Edition M
4.2.1.1 Unadditized JP-8 fuel using a matrix of SDA, FSII and CI/LI fuel additives.

4.2.1.1.1 Unadditized JP-8 fuel

4.2.1.1.2 Unadditized JP-8 fuel using SDA

4.2.1.1.3 Unadditized JP-8 fuel using FSII

4.2.1.1.4 Unadditized JP-8 fuel using CI/LI

4.2.1.1.5 Unadditized JP-8 fuel using SDA/FSII

4.2.1.1.6 Unadditized JP-8 fuel using SDA/CI/LI

4.2.1.1.7 Unadditized JP-8 fuel using FSII/CI/LI

4.2.1.1.8 Unadditized JP-8 fuel using SDA/CI/LI/FSII

4.2.1.1.9 Unadditized JP-8 fuel using SDA/CI/LI/FSII with 45/45 (90%) blend of Arizona A1 and A3 test dust and 10% Copperas Red Iron Oxide

Unadditized JP-8	Neat	SDA only	FSII only	CI/LI only	SDA/FSII only	SDA/CI/LI only	FSII/CI/LI only	SDA/CI/LI/FSII	SDA/CI/LI/FSII w/ 45/45 A1&A3 dirt
Test 1	X								
Test 2		X							
Test 3			X						
Test 4				X					
Test 5					X				
Test 6						X			
Test 7							X		
Test 8								X	
Test 9									X

4.2.2 API/IP 5th Edition M

4.2.2.1 Unadditized HRJ fuel and M-Category fuel blend (50% by volume of each respective fuel) using a matrix of SDA, FSII and CI/LI fuel additives.

4.2.2.1.1 Unadditized 50/50 blend fuel

4.2.2.1.2 Unadditized 50/50 blend using SDA

4.2.2.1.3 Unadditized 50/50 blend using FSII

4.2.2.1.4 Unadditized 50/50 blend CI/LI

4.2.2.1.5 Unadditized 50/50 blend SDA/FSII

4.2.2.1.6 Unadditized 50/50 blend SDA/CI/LI

4.2.2.1.7 Unadditized 50/50 blend FSII/CI/LI

4.2.2.1.8 Unadditized 50/50 blend SDA/CI/LI/FSII

4.2.2.1.9 Unadditized 50/50 blend SDA/CI/LI/FSII with 45/45 (90%) blend of Arizona A1 and A3 test dust and 10% Copperas Red Iron Oxide

Unadditized HRJ/JP-8 50/50 blend	Neat	SDA only	FSII only	CI/LI only	SDA/FSII only	SDA/CI/LI only	FSII/CI/LI only	SDA/CI/LI/FSII	SDA/CI/LI/FSII w/ 45/45 A1&A3 dirt
Test 1	X								
Test 2		X							
Test 3			X						
Test 4				X					
Test 5					X				
Test 6						X			
Test 7							X		
Test 8								X	
Test 9									X

5.0 Deliverables for F/S Testing

5.1 The contractor shall provide informal monthly teleconference updates and bi-monthly progress reports. If less time is needed to complete the testing, then informal teleconference will be scheduled half way through the testing protocol.

5.2 The contractor shall prepare the following reviews/presentations for Air Force review and comment:

5.2.1 A kick-off review wherein the contractor shall review all testing assumptions, protocols and procedures that will be used during this program

5.2.2 A mid-program review presentation to be given at a time and location agreed to by the contractor and Air Force.

5.2.3 A final report with recommendations shall be prepared and provided to the Air Force

5.2.4 The final report shall present all data and shall make recommendations for the filter/coalesce type regarding its suitability for each type of fuel and each additive.

5.2.5 The contractor shall also prepare a presentation to accompany the final report covering the results of this work.

5.2.6 A public release version of the final report and final presentation shall be prepared and provided to the Air Force.

Appendix C

Materials Compatibility Test Results

Existent Gum

API/IP 3rd Edition

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	2.2 mg/100 mL	2.4 mg/100 mL	2.5 mg/100 mL	2.3 mg/100mL
50/50 HRJ/JP-8 Blend	1.3 mg/100 mL	1.6 mg/100 mL	1.4 mg/100mL	1.7 mg/100 mL
50 HRJ/ JP-8+100 Blend	0.9 mg/100 mL	1.2 mg/100 mL	1.2 mg/100 mL	1.4 mg/100 mL

API/IP 5th Edition M Category

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	2.0 mg/100 mL	2.4 mg/100 mL	2.4 mg/100 mL	2.6 mg/100 mL
50/50 HRJ/JP-8 Blend	0.5 mg/100 mL	1.0 mg/100 mL	1.2 mg/100 mL	0.9 mg/100 mL
50 HRJ/ JP-8+100 Blend	0.8 mg/100 mL	1.1 mg/100 mL	1.4 mg/100 mL	0.8 mg/100 mL

API/IP 5th Edition M100 Category

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	2.4 mg/100 mL	2.7 mg/100 mL	2.0 mg/100 mL	2.3 mg/100 mL
50/50 HRJ/JP-8 Blend	1.5 mg/100 mL	2.2 mg/100 mL	2.6 mg/100 mL	1.9 mg/100 mL
50 HRJ/ JP-8+100 Blend	2.1 mg/100 mL	2.2 mg/100 mL	2.4 mg/100 mL	2.5 mg/100 mL

MSEP

API/IP 3rd Edition

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	98	95	96	97
50/50 HRJ/JP-8 Blend	75	65	0	68
50 HRJ/ JP-8+100 Blend	0	0	0	0

API/IP 5th Edition M Category

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	99	95	97	96
50/50 HRJ/JP-8 Blend	70	0	0	58
50 HRJ/ JP-8+100 Blend	0	0	0	0

API/IP 5th Edition M100 Category

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	97	94	94	96
50/50 HRJ/JP-8 Blend	66	70	51	0
50 HRJ/ JP-8+100 Blend	0	0	0	0

Color

API/IP 3rd Edition

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	+28	+28	+29	+28
50/50 HRJ/JP-8 Blend	+23	+23	+23	+23
50 HRJ/ JP-8+100 Blend	+23	+24	+23	+24

API/IP 5th Edition M Category

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	+29	+28	+28	+28
50/50 HRJ/JP-8 Blend	+23	+24	+23	+23
50 HRJ/ JP-8+100 Blend	+23	+23	+24	+23

API/IP 5th Edition M100 Category

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	+28	+28	+29	+28
50/50 HRJ/JP-8 Blend	+24	+23	+23	+23
50 HRJ/ JP-8+100 Blend	+23	+23	+22	+23

Water Reaction Tests

API/IP 3rd Edition

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	1 Separation 1 Interface	1 Separation 1 Interface	1 Separation 1 Interface	1 Separation 1 Interface
50/50 HRJ/JP-8 Blend	2 Separation 1 Interface	2 Separation 1 Interface	2 Separation 1 Interface	2 Separation 1 Interface
50 HRJ/ JP-8+100 Blend	3 Separation 3 Interface	3 Separation 3 Interface	3 Separation 3 Interface	3 Separation 3 Interface

API/IP 5th Edition M Category

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	1 Separation 1 Interface	1 Separation 1 Interface	1 Separation 1 Interface	1 Separation 1 Interface
50/50 HRJ/JP-8 Blend	2 Separation 1 Interface	2 Separation 1 Interface	2 Separation 1 Interface	2 Separation 1 Interface
50 HRJ/ JP-8+100 Blend	3 Separation 3 Interface	3 Separation 3 Interface	3 Separation 3 Interface	3 Separation 3 Interface

API/IP 5th Edition M100 Category

Fuel	Initial Soak – 0 Hours	Initial Soak – 336 Hours	Second Soak – 0 Hours	Second Soak – 336 Hours
Neat HRJ	1 Separation 1 Interface	1 Separation 1 Interface	1 Separation 1 Interface	1 Separation 1 Interface
50/50 HRJ/JP-8 Blend	2 Separation 1 Interface	2 Separation 1 Interface	2 Separation 1 Interface	2 Separation 1 Interface
50 HRJ/ JP-8+100 Blend	3 Separation 3 Interface	3 Separation 3 Interface	3 Separation 3 Interface	3 Separation 3 Interface

Appendix D

Water Coalescing Effectiveness Test Procedure

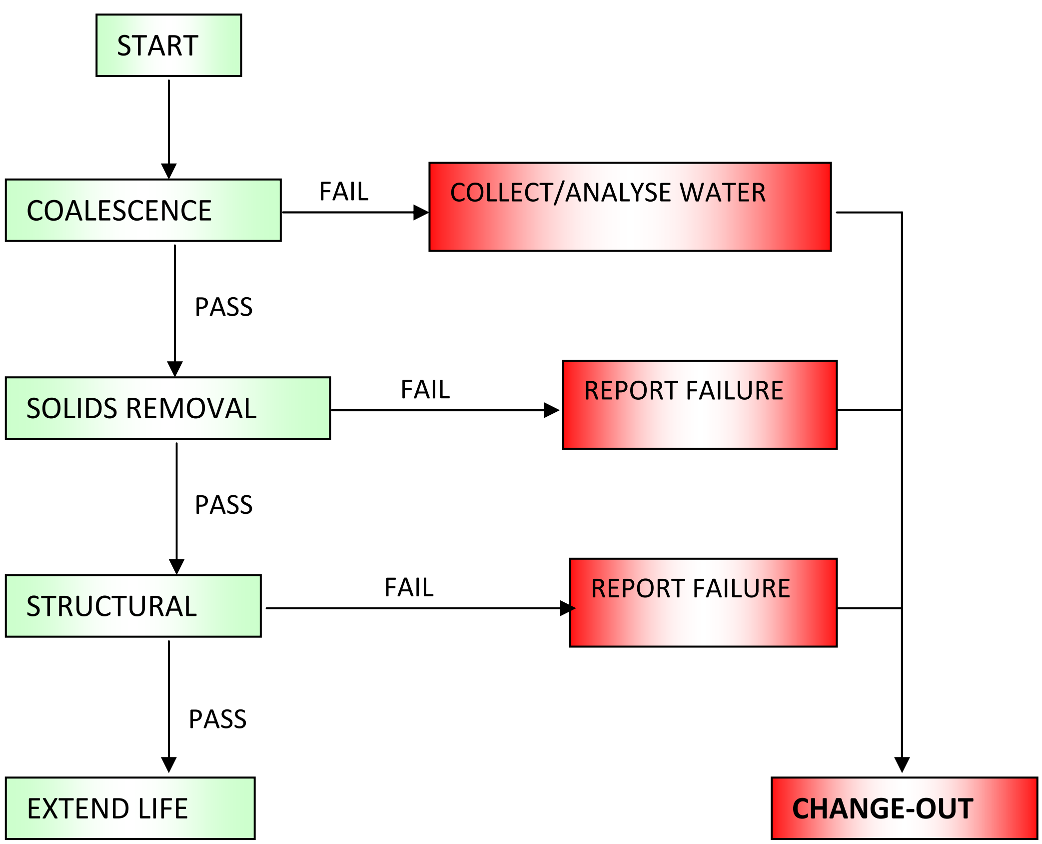
Test Protocol for Evaluating Stored Test Elements

Objective: Create cost benefit by extending filter element operational life to 5 years.

Application: To filter elements not reaching change-out differential pressure (DP) within usual recommended operational life. The test protocol described below is applied for each element model type at each location or fuel system. Some airports have more than one fuel source and will require separate assessments for each. Some operations use more than one model of element and again will require a separate assessment for each. This process may be invoked at the end of the 3rd, 4th and 5th year of service life. Once sufficient data have been accumulated for the particular element model at the particular location to support life extension the testing intensity may be reduced.

Strategy: Develop a procedure to validate extended operational performance of filter elements.

Requirements: A minimum number of filter elements have to be removed otherwise there is no or reduced cost benefit. The element has to be tested for level of disarming (if any), level of particulate blocking and structural stability. These aspects can be tested on one element, unambiguously if the correct sequence of tests is conducted. The sequence of tests is as follows:



Test Methods:

START: The test element is installed in a suitable test vessel. Test fuel is pumped through the element at its rated flow. When the flow is steady, the differential pressure is noted and compared with that of a new element. An increase reflects the level of fine particulate captured.

COALESCENCE: Immediately after establishing steady flow, 0.01% water is introduced upstream of the main pump. If fine droplets ("smoke") appear from the body of the element, it has been disarmed by surfactants. (Note, sometimes it is difficult to make a good seal on an element which has been in service and so it is possible that sometimes the smoke comes from the end cap seals. If this happens the element should be re-seated to make a good seal.) If no smoke appears, the water flow rate should be increased to 1% after about 20 minutes. Coalesced droplets should appear shortly after. If "smoke" has appeared, the water concentration should be immediately increased to 1 % and any coalesced water that does eventually accumulate can be isolated and analyzed for surfactants. Downstream Aquaglo measurements should be made as frequently as possible and if values greater than 15ppm are obtained the element can be considered disarmed.

SOLIDS REMOVAL: After the water test, water injection is discontinued and test dust from a slurry tank is introduced to the test system. Downstream gravimetric analysis will indicate the level of solids transmission, which should be less than 0.26mg/l. Testing is continued up to a dP of 45psi. Excessive transmission terminates the test and the element should be cut open to find the cause of the transmission (failed seam or failed end-cap bond, etc).

STRUCTURAL: Solids addition is continued to a differential pressure of 75psid and a visual assessment is made of the structure.

Appendix E

Water Coalescing Effectiveness Test Results

New API/EI 1581 3rd Edition Element Test Results

Time, minutes	Flow Rate, gpm	DP, psid	Conductivity, pS/m	Water content, ppm	Solids Content, mg/L	Temp, ºF
Clean Fuel						
0	33.9	6.7	590	1		66
5	34.9	6.7	592	1		66
10	33.9	6.6	594	1		66
15	33.9	6.6	587	1		66
20	33.9	6.7	592	0.1		66
Coalescence, 100-ppm						
0	33.9	6.7	585	0.1		66
5	33.9	7.3	590	0.1		66
10	33.8	7.8	593	0.2		67
15	33.8	8.1	588	0.6		67
20	33.9	8.4	591	0.8		67
Coalescence – 1%						
0	34.0	8.2	593	0.6		67
5	34.3	12.4	595	34.5		67
10						
15						
20						
Solids, 19 mg/L						
0						
15						
15 s/s						
30						
30 s/s						
45						
45 s/s						
60						
60 s/s						
75						
75s/s						
Structural – 75 psid						

Aged API/EI 1581 3rd Edition Element Test Results

Time, minutes	Flow Rate, gpm	DP, psid	Conductivity, pS/m	Water content, ppm	Solids Content, mg/L	Temp, ºF
Clean Fuel						
0	34.1	6.4	612	0		68
5	34.2	6.6	600	0		67
10	34.3	6.8	621	0		67
15	34.3	7.0	640	0		67
20	34.2	7.0	635	0		67
Coalescence, 100-ppm						
0	34.1	7.0	630	0		67
5	34.2	7.8	639	0.1		67
10	34.2	8.5	632	1		67
15	34.1	8.7	627	0.2		67
20	34.0	9.0	635	0.3		67
Coalescence – 1%						
0	34.1	8.9	638	0.1		67
5	34.3	11.5	630	82		68
10	34.4	12.2	627	148		68
15						
20						
Solids, 19 mg/L						
0						
15						
15 s/s						
30						
30 s/s						
45						
45 s/s						
60						
60 s/s						
75						
75s/s						
Structural – 75 psid						

New API/EI 1581 5th Edition Category M Element Test Results

Time, minutes	**Flow Rate, gpm**	**DP, psid**	**Conductivity, pS/m**	**Water content, ppm**	**Solids Content, mg/L**	**Temp, ºF**
Clean Fuel						
0	34.2	4.5	592	0.1		68
5	34.2	4.5	590	0		68
10	34.2	4.5	593	0		68
15	34.2	4.5	590	0		69
20	34.2	4.5	588	0.1		69
Coalescence, 100-ppm						
0	34.2	4.5	591	0		69
5	34.1	4.8	594	0.1		68
10	34.0	5.2	591	0.1		68
15	34.0	5.5	587	0.2		68
20	34.0	5.7	592	0.1		68
Coalescence – 1%						
0	33.9	5.6	594	0.1		68
5	34.3	8.3	588	82		69
10	34.3	8.7	597	98		69
15	34.2	9.5	601	152		69
20						
Solids, 19 mg/L						
0						
15						
15 s/s						
30						
30 s/s						
45						
45 s/s						
60						
60 s/s						
75						
75s/s						
Structural – 75 psid						

Aged API/EI 1581 5th Edition Category M Element Test Results

Time,	**Flow**	**DP,**	**Conductivity,**	**Water**	**Solids**	**Temp, ºF**

minutes	Rate, gpm	psid	pS/m	content, ppm	Content, mg/L	
Clean Fuel						
0	33.8	5.1	622	0		67
5	33.9	5.2	630	0		68
10	34.1	5.3	627	0.1		68
15	34.2	5.4	633	0.1		68
20	34.3	5.5	637	0.1		68
Coalescence, 100-ppm						
0	34.2	5.5	630	0.1		68
5	34.1	5.7	622	0.1		68
10	34.3	6.2	617	0.3		68
15	34.2	6.6	632	0.4		68
20	34.3	6.8	626	0.3		68
Coalescence – 1%						
0	34.2	6.7	633	0.2		68
5	34.2	8.2	630	61.5		68
10	34.2	8.9	622	109		68
15						
20						
Solids, 19 mg/L						
0						
15						
15 s/s						
30						
30 s/s						
45						
45 s/s						
60						
60 s/s						
75						
75s/s						
Structural – 75 psid						

New API/EI 1581 5th Edition Category M100 Element Test Results

Time, minutes	Flow Rate,	DP, psid	Conductivity, pS/m	Water content,	Solids Content,	Temp, ºF

	gpm			ppm	mg/L	
Clean Fuel						
0	34.2	4.8	617	0		67
5	34.1	4.9	624	0		67
10	33.9	5.0	623	0		67
15	34.0	5.1	615	0		68
20	34.0	5.1	622	0		68
Coalescence, 100-ppm						
0	34.0	5.1	607	0		68
5	33.9	5.3	612	0		68
10	34.2	5.6	622	0.1		68
15	34.0	6.0	616	0.1		68
20	34.0	6.2	620	0.1		68
Coalescence – 1%						
0	33.9	6.3	615	0.1		68
5	34.3	8.2	624	1.2		68
10	34.2	8.9	619	3.7		68
15	34.2	9.5	612	7.8		68
20	34.3	9.9	618	12.2		68
Solids, 19 mg/L						
0	34.1	8.6	613		0	68
15	34.3	9.4	620		0	68
15 s/s	34.5	9.8	624		0.025	68
30	33.9	11.9	615		0.05	68
30 s/s	34.5	12.4	621		0.025	68
45	33.8	18.5	619		0.1	68
45 s/s	34.3	19.9	---		0.075	68
60	34.1	26.5	625		0.05	68
60 s/s	34.4	28.3	---		0.125	68
75	34.0	34.9	617		0.05	68
75s/s	34.3	35.3	---		0.075	68
Structural – 75 psid						
95	33.9	75.3				68

Aged API/EI 1581 5th Edition Category M100 Element Test Results

Time, minutes	Flow Rate, gpm	DP, psid	Conductivity, pS/m	Water content, ppm	Solids Content, mg/L	Temp, ºF

Clean Fuel						
0	34.2	4.7	607	0.3		66
5	34.2	4.8	592	0.2		66
10	34.1	4.8	599	0.1		65
15	34.2	5.0	610	0.1		65
20	34.2	5.2	607	0.1		65
Coalescence, 100-ppm						
0	34.2	5.2	611	0.2		65
5	34.2	5.8	605	0.2		65
10	34.2	6.2	612	0.4		65
15	34.1	6.7	613	0.2		66
20	34.1	6.9	620	0.1		66
Coalescence – 1%						
0	34.2	6.9	621	0		66
5	34.0	9.2	622	21.6		66
10	34.1	9.8	617	32		66
15	34.0	10.1	611	44		66
20	33.9	10.6	618	44		66
Solids, 19 mg/L						
0						
15						
15 s/s						
30						
30 s/s						
45						
45 s/s						
60						
60 s/s						
75						
75s/s						
Structural – 75 psid						

Appendix F

Phase I Single Element Test Results

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Test 1 - 3rd Edition Element

5th Edition Single Element Data Sheet

Test Specification: API/IP 1581 5th Edition		SET: ■			Date: 11/5/10
Test No. 106		Full-Scale: ☐			
Vessel:		Filter/Coalescer: Velcon		Separator: Velcon	Type: ■-S ☐S-LD
Additive Addition		Model: I61487TB		Model: SO606C	Manufacturing Date:

Category:		M-100 ☐				M ■				C ☐			
Tank Volume	Gallons	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)
Beginning	13,550	A	256			D	2,0	102.6 g		I	1,0		
Ending		B	0,15%			B	0,15%	20.3 gal		II	15		
		C	15			C	15	769.4 g					
Used		D	2,0										
Mixing Time: 30 minutes							WISM	Before	After				
Element Conditioning:		■ in-Situ		☐ External				98	68				

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ☐ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp °C ☐ °F ■
Start-up	0	0	33.8	6.9	570/194								62
Water 0,01%	5	0	34	6.9	574/245		0.2						
	10	5	33.9	7.2		12.9	0.2						
	15	10 s/s	34.3	8.3		12.9	0.9						
	25	20 s/s	34.3	8.7		12.9	1.1						
	35	30 s/s	34.3	9.2	571/427	12.9	3.5						62

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp °C ☐ °F ■
Solids Holding Test (Continued until reaching 115 kPa (22,5 psid)	35	0	33.8	8.7	569/429								62
	50	15	33.9	9.5				19	2		0	4L	63
		15 s/s	34.3	9.6				19	3		0	4L	
	65	30	34.1	11	557/467			19	4		0.025	4L	
		30 s/s	34.2	11.4				19	5		0	4L	
	80	45	34.2	13.7				19	6		0	4L	
		45 s/s	34.2	15.7				19	7		0.025	4L	
	85	50	34	17.1									
	95	60	34.1	19.7	562/490			19	8		0	4L	63
		60 s/s	34.2	20.7				19	9		0.025	4L	
	110	75	34	24.1				19	10		0.05	4L	
		75 s/s	34	26				19	11		0.025	4L	

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp °C ☐ °F ■
Water Coalescence Test - 0.01%	110	0	34.2	25.4	579/514		C						64
	112	2	34	33.9		12.9	0.4						
	115	4	34.1	44.2		12.9	7.8						
	125	15	34.2	57.1		12.9	25						
		30 s/s	34.3	61.1	565/535	12.9	43.6						64
	155	45	33.8	69.5		12.9	43.7						
	170	60 s/s	34.1	71	597/576	12.9	43.7						
	185	75	34.1	77.2		12.9	43.8						
		90 s/s	34	74.7		12.9	43.8						66
	215	105	34.1	77.4	591/580	12.9	43.7						
		120 s/s	34.2	77.1		12.9	43.7						
	245	135	34.1	84.2		12.9	washout						
		150 s/s	34.1	80.4		12.9	washout						
Water Coalescence Test - 3%	260	0	34.1	55.7	596/608	0	2.6						
	262	2	32.1	97.4		3.9 lpm	washout						67
	265	5	32.7	106.4		3.9 lpm	washout						
		10 s/s	31	106.5	597/625	3.9 lpm	washout						
		20 s/s	29.4	106.8		3.9 lpm	washout						68
	290	30				3.9 lpm							

Notes/Comments:

Test 2 - 5th Edition M Element

5th Edition Single Element Data Sheet

Test Specification: API/IP 1581 5th Edition	SET: ■		Date: 12/16/10
Test No. 106	Full-Scale: ☐		
Vessel:	Filter/Coalescer: Velcon	Separator: Velcon	Type: ■-S ☐S-LD
Additive Addition	Model: I614MMTB	Model: SO606C	Manufacturing Date:

Category:	M-100 ☐				M ■				C ☐				
Tank Volume	Gallons	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)
Beginning	12,390	A	256			D	2,0	93.8 g		I	1,0		
Ending		B	0,15%			B	0,15%	18.6 gal		II	15		
		C	15			C	15	703.5 g					
Used		D	2,0										
Mixing Time: 30 minutes							WISM	Before	After				
Element Conditioning:		■ in-Situ		☐ External				99	62				

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ☐ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp ☐ °C ■ °F
Start-up	0	0	34	4.4	536/215								67
Water 0,01%	5	0	34	4.4	550/294		0.1						
	10	5	33.9	4.6		12.9	0.1						
	15	10 s/s	34.3	5.1		12.9	0.1						
	25	20 s/s	34	5.5		12.9	0.2						
	35	30 s/s	34.3	5.8	549/437	12.9	0.3						67

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp ☐ °C ■ °F
Solids Holding Test (Continued until reaching 115 kPa (22,5 psid)	35	0	34	5.6	548/460								67
	50	15	33.9	6.3				19	2		0	4L	67
		15 s/s	33.9	6.4				19	3		0	4L	
	65	30	34	7.1	552/510			19	4		0.025	4L	
		30 s/s	34.4	7.5				19	5		0.025	4L	
	80	45	34.1	8.5				19	6		0	4L	
		45 s/s	34.3	8.7				19	7		0.075	4L	
	85	50	33.9	9.2									
	95	60	33.8	11.3	567/548			19	8		0.025	4L	67
		60 s/s	34	12				19	9		0	4L	
	110	75	34.2	15.2				19	10		0.025	4L	
		75 s/s	34.4	15.3				19	11		0	4L	

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp ☐ °C ■ °F
Water Coalescence Test - 0 01%	110	0	34.3	14.2	560/548		0.3						73
	112	2	34.2	15.7		12.9	0.3						
	115	4	34.2	16.2		12.9	0.6						
	125	15	33.8	18.1		12.9	0.8						
		30 s/s	34.2	19	557/550	12.9	1.2						73
	155	45	34	21.9		12.9	0.4						
	170	60 s/s	34.1	22.4	578/580	12.9	1						
	185	75	33.9	24.7		12.9	0.4						
		90 s/s	34.3	25.4		12.9	2.5						72
	215	105	33.9	28	555/597	12.9	0.8						
		120 s/s	34.3	27.9		12.9	6.8						
	245	135	33.9	30		12.9	1.7						
		150 s/s	33.8	29.5		12.9	15.2						
Water Coalescence Test - 3%	260	0	34.3	23.7	556/580	0	0.6						
	262	2	34.3	41.9		3.9 lpm	4.75						71
	265	5	33.8	49		3.9 lpm	41						
		10 s/s	34.2	59.4	560/618	3.9 lpm	washout						
		20 s/s	34.5	75.1		3.9 lpm	washout						
	290	30				3.9 lpm							Test

Notes/Comments:

Test 3 - 5th Edition M100 Element

5th Edition Single Element Data Sheet

Test Specification: API/IP 1581 5th Edition				SET: ■								Date: 12/3/10	
Test No. 106				Full-Scale: □									
Vessel:			Filter/Coalescer: Velcon				Separator: Velcon					Type: ■-S □S-LD	
Additive Addition			Model: 614A4TB				Model: SO606C					Manufacturing Date:	
Category:		M-100 ■				M □				C □			
Tank Volume	Gallons	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)
Beginning	12,700	A	256	12,307 g		D	2,0			I	1,0		
Ending		B	0,15%	19 gal		B	0,15%			II	15		
		C	15	721 g		C	15						
Used		D	2,0	96.2 g									
Mixing Time: 30 minutes							WISM	Before	After				
Element Conditioning:		■ in-Situ		□ External				96	0				

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min □ gpm	Water Concent. (ppm)	Solids Rate □ mg/L □ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp □ °C ■ °F
Start-up	0	0	33.9	4.8	490/380								67
Water 0,01%	5	0	33.8	4.8	494/420		0						
	10	5	34	5.1		12.9	0.4						
	15	10 s/s	34	5.4		12.9	0.1						
	25	20 s/s	34.2	6		12.9	0.5						
	35	30 s/s	34.2	6.1	439/435	12.9	0.6						68

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min □ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L □ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp □ °C ■ °F
Solids Holding Test (Continued until reaching 115 kPa (22,5 psid)	35	0	34.1	6.1	448/437								68
	50	15	34	7				19	2		0.025	4L	69
		15 s/s	33.9	8.4				19	3		0.025	4L	
	65	30	34.3	10.8	457/460			19	4		0	4L	
		30 s/s	34.1	11.4				19	5		0.1	4L	
	80	45	33.9	14.2				19	6		0.025	4L	
		45 s/s	34.3	15				19	7		0.125	4L	
	85	50	34	15.6									
	95	60	34	17.1	451/463			19	8		0.025	4L	69
		60 s/s	34.3	17.6				19	9		0.05	4L	
	110	75	33.9	19.2				19	10		0.075	4L	
		75 s/s	34.4	19.7				19	11		0.15	4L	

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min □ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L □ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp □ °C ■ °F
Water Coalescence Test - 0 01%	110	0	33.9	18.7	456/463		0.3						70
	112	2	33.8	21.2		12.9	0.5						
	115	4	33.9	28.5		12.9	0.4						
	125	15	33.8	33.9		12.9	0.4						
		30 s/s	34.3	36.3	459/455	12.9	0.6						70
	155	45	34.1	41.8		12.9	0.5						
	170	60 s/s	34.2	38	462/459	12.9	1.1						
	185	75	33.8	43.2		12.9	0.6						
		90 s/s	34.3	40.6		12.9	2.3						71
	215	105	33.8	45.1	466/475	12.9	0.6						
		120 s/s	34.3	42.2		12.9	3.6						
	245	135	33.8	46.1		12.9	1.1						
		150 s/s	34.2	41.6		12.9	4.1						
Water Coalescence Test - 3%	260	0	33.9	36.4	476/482	0	0.7						
	262	2	34	47		3.9 lpm	5.6						73
	265	5				3.9 lpm							
		10 s/s				3.9 lpm							
		20 s/s				3.9 lpm							
	290	30				3.9 lpm							

Notes/Comments: End cap blew at ~60psid and 2.5 minutes

Test 4 - 5th Edition M Element - No Additives

5th Edition Single Element Data Sheet

Test Specification: API/IP 1581 5th Edition		SET: [■]		Date: 11/23/10
Test No.		Full-Scale: [ ]		
Vessel:		Filter/Coalescer: Velcon	Separator: Velcon	Type: [■]-S [ ]S-LD
Additive Addition		Model: I614MMTB	Model: SO606C	Manufacturing Date:

Category:		M-100 [ ]				M [ ]				C [ ]			
Tank Volume	Gallons	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)
Beginning	13,550	A	256			D				I	1,0		
Ending		B	0,15%			B				II	15		
		C	15			C							
Used		D	2,0										

Mixing Time: 30 minutes	WISM	Before	After
Element Conditioning: [■] in-Situ [ ] External		99	n/a

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate [■] mL/min [ ] gpm	Water Concent. (ppm)	Solids Rate [ ] mg/L [ ] mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp [ ] °C [■] °F
Start-up	0	0	34.3	4.6	23/9								79
Water 0,01%	5	0	34.5	4.5	21/9		0.2						
	10	5	34.3	4.8		12.9	0.2						
	15	10 s/s	34.3	5.1		12.9	0.6						
	25	20 s/s	34.3	5.4		12.9	0.7						
	35	30 s/s	34.2	5.6	21/16	12.9	0.6						79

Notes/Comments: No additive package added to the 50/50 blend

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate [■] mL/min [ ] gpm	Water Concent. (ppm)	Solids Rate [■] mg/L [ ] mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp [ ] °C [■] °F
Solids Holding Test (Continued until reaching 115 kPa (22,5 psid)	35	0	34.3	5.6	21/16								79
	50	15	34	6				19	2		0.025	4L	77
		15 s/s	34.2	6.2				19	3		0	4L	
	65	30	33.8	7.1	21/19			19	4		0	4L	
		30 s/s	34.5	7.5				19	5		0.025	4L	
	80	45	33.9	8.4				19	6		0.05	4L	
		45 s/s	34.3	8.9				19	7		0	4L	
	85	50	34.1	9.1									
	95	60	33.9	9.3	21/9			19	8		0	4L	76
		60 s/s	33.9	9.6				19	9		0.025	4L	
	110	75	34	10.2				19	10		0.05	4L	
		75 s/s	34.4	10.4				19	11		0	4L	

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate [■] mL/min [ ] gpm	Water Concent. (ppm)	Solids Rate [■] mg/L [ ] mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp [ ] °C [■] °F
Water Coalescence Test - 0 01%	110	0	34.1	10.1	20/10		0.2						75
	112	2	33.8	11.1		12.9	0.3						
	115	4	33.9	11.3		12.9	0.3						
	125	15	34.1	11.9		12.9	0						
		30 s/s	34.7	12.1	19/11	12.9	0.2						75
	155	45	34	12.1		12.9	0						
	170	60 s/s	34.6	11.9	20/12	12.9	0.1						
	185	75	33.9	12.1		12.9	0						
		90 s/s	34.3	11.9		12.9	0.2						74
	215	105	34.1	12.1	19/11	12.9	0						
		120 s/s	34.4	12.1		12.9	0.1						
	245	135	34	12.1		12.9	0						
		150 s/s	34.2	12		12.9	0						
Water Coalescence Test - 3%	260	0	34.1	12	19/10	0	0						
	262	2	34.3	21.3		3.9 lpm	0.2						76
	265	5	34	23.4		3.9 lpm	0.3						
		10 s/s	33.8	23.3	19/19	3.9 lpm	0.5						
		20 s/s	34	25.1		3.9 lpm	0.7						
	290	30	34	27.8	19/20	3.9 lpm	0.4						72

Test 5 - 5th Edition M Element - Different Lot

5th Edition Single Element Data Sheet

Test Specification: API/IP 1581 5th Edition				SET: ■								Date: 11/24/10	
Test No. 106				Full-Scale: ☐									
Vessel:			Filter/Coalescer: Velcon					Separator: Velcon				Type: ■-S ☐S-LD	
Additive Addition			Model: I614MMTB (OLD Batch)					Model: SO606C				Manufacturing Date:	
			Old Batch of elements 02 02 09										
Category:		M-100 ☐				M ■				C ☐			
Tank Volume	Gallons	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)
Beginning	13,550	A	256			D	2,0	102.6 g		I	1,0		
Ending		B	0,15%			B	0,15%	20.3 gal		II	15		
		C	15			C	15	769.4 g					
Used		D	2,0										
Mixing Time: 30 minutes							WISM	Before	After				
Element Conditioning:		■ in-Situ		☐ External				97	67				

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ☐ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp ☐ °C ■ °F
Start-up	0	0	34.3	4.5	732/201								78
Water 0,01%	5	0	34.3	4.5	734/205		0.1						
	10	5	34.3	4.9		12.9	0.1						
	15	10 s/s	34.3	5.1		12.9	0.2						
	25	20 s/s	34.4	5.5		12.9	0.2						
	35	30 s/s	34.3	5.6	728/589	12.9	0.3						78

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp ☐ °C ■ °F
Solids Holding Test (Continued until reaching 115 kPa (22,5 psid)	35	0	34.3	5.4	730/594								78
	50	15	33.9	6.1				19	2		0	4L	79
		15 s/s	34.3	6.2				19	3		0	4L	
	65	30	33.9	8	734/630			19	4		0	4L	
		30 s/s	34.1	8.1				19	5		0.05	4L	
	80	45	34.2	12.1				19	6		0.05	4L	
		45 s/s	34.2	12.9				19	7		0.025	4L	
	85	50	34	13.9									
	95	60	34.1	16.4	724/680			19	8		0	4L	79
		60 s/s	34.2	17.7				19	9		0	4L	
	110	75	34.1	21.2				19	10		0.05	4L	
		75 s/s	34	22.2				19	11		0	4L	

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp ☐ °C ■ °F
Water Coalescence Test - 0 01%	110	0	34	22.2	731/704		0						79
	112	2	34.3	30.3		12.9	1						
	115	4	34.3	35		12.9	1.9						
	125	15	33.9	43.8		12.9	1.7						
		30 s/s	34	45.5	733/721	12.9	0.6						79
	155	45	33.8	53.2		12.9	0.5						
	170	60 s/s	34	51.5	758/730	12.9	14.7						
	185	75	34.2	60.2		12.9	3.3						
		90 s/s	34.4	56.7		12.9	39						78
	215	105	33.9	63.5	750/739	12.9	4						
		120 s/s	34	60.4		12.9	55						
	245	135	34	65.9		12.9	16						
		150 s/s	34.3	62.5		12.9	211						
Water Coalescence Test - 3%	260	0	34	58.7	781/770	0	1.9						
	262	2	34.2	88.2		3.9 lpm	81.2						78
	265	5	33.9	92.7		3.9 lpm	85						
		10 s/s	34.3	92.9	792/774	3.9 lpm	211						
		20 s/s	*			3.9 lpm							
	290	30				3.9 lpm							

*** Note: Structural failure at ~120 psid**

Test 6 - 5th Edition M Element - Different Supplier

5th Edition Single Element Data Sheet

Test Specification: API/IP 1581 5th Edition				SET: ■								Date: 12/21/10	
Test No. 106				Full-Scale: ☐									
Vessel:			Filter/Coalescer: Facet				Separator: Velcon					Type: ■ S ☐ S-LD	
Additive Addition			Model: TC-C0162				Model: SO606C					Manufacturing Date:	
Category:		M-100 ☐				M ■				C ☐			
Tank Volume	Gallons	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)	Additive	Conc. (Mg/L)	Amount Added	k (pS/m)
Beginning	12,000	A	256			D	2,0	90.85 g		I	1,0		
Ending		B	0,15%			B	0,15%	18 gal		II	15		
		C	15			C	15	681.4 g					
Used		D	2,0										
Mixing Time: 30 minutes							WISM	Before	After				
Element Conditioning:		■ in-Situ		☐ External				98	65				

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ☐ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp ☐ °F ■ °C
Start-up	0	0	33.9	6.7	651/178								72
Water 0,01%	5	0	33.9	6.8	645/201		0.1						
	10	5	33.9	7.1		12.9	0.1						
	15	10 s/s	34.3	7.8		12.9	0.2						
	25	20 s/s	34.3	8.1		12.9	0.3						
	35	30 s/s	34.3	8.5	639/299	12.9	0.5						72

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp ☐ °F ■ °C
Solids Holding Test (Continued until reaching 115 kPa (22,5 psid)	35	0	34	8.3	635/305								72
	50	15	34	9.5				19	2		0.025	4L	71
		15 s/s	34.3	9.9				19	3		0	4L	
	65	30	34	14.3	642/343			19	4		0.025	4L	
		30 s/s	34.4	14.9				19	5		0	4L	
	80	45	34	21.4				19	6		0.05	4L	
		45 s/s	34.3	22.5				19	7		0	4L	
	85	50	34	24.2									
	95	60	33.9	27	640/381			19	8		0.025	4L	71
		60 s/s	34.5	27.3				19	9		0.025	4L	
	110	75	34	33.2				19	10		0.05	4L	
		75 s/s	34	32.4				19	11		0	4L	

Notes/Comments:

Phase	Cum. Test Time (minutes)	Time (minutes)	Fuel Flow Rate (gpm)	ΔP (psid)	k (pS/m)	Water Flow Rate ■ mL/min ☐ gpm	Water Concent. (ppm)	Solids Rate ■ mg/L ☐ mg/gal	Filter Sample ID	Solids Concent. Affluent (mg/L)	Solids Concent. Effluent (mg/L)	Sample Size	Temp ☐ °F ■ °C
Water Coa escence Test - 0 01%	110	0	34.3	32.7	633/402		0.2						70
	112	2	33.9	34.1		12.9	0.4						
	115	4	33.8	34.7		12.9	0.3						
	125	15	34.2	37.8		12.9	1.4						
		30 s/s	34.4	38	640/439	12.9	4.1						70
	155	45	34	40.5		12.9	3.4						
	170	60 s/s	34.3	40.2	635/462	12.9	10.5						
	185	75	34	42.5		12.9	6.5						
		90 s/s	34.4	42.4		12.9	14.5						69
	215	105	34.2	44.7	642/520	12.9	12.7						
		120 s/s	34.5	44		12.9	40.8						
	245	135	34.2	46.1		12.9	12.2						
		150 s/s	34.2	45.5		12.9	42.7						
Water Coalescence Test - 3%	260	0	33.9	42.4	633/531	0	2.8						
	262	2	34	51.2		3.9 lpm	63						69
	265	5	34.2	57.1		3.9 lpm	68						
		10 s/s	34.4	59.5	620/569	3.9 lpm	washout						
		20 s/s	34.2	66.6		3.9 lpm	washout						
	290	30	34.4	72.5	617/571	3.9 lpm	washout						69

Notes/Comments:

Appendix G

Phase I Fuel and Additive Sample Test Results

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2010LA29085002 Date Received:12/22/10 1211 hrs* Date Sampled: 12/17/2010**
Cust Sample No:HRJ:CLAYTREATED Date Reported:01/11/11 1047 hrs* Protocol:FU-AVI-0123
(WITHOUT ADDITIVES)

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: HRJ Testing
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Qty Submitted: 1 gal

Method	Test	Min	Max	Result	Fail
ATP	Hy-Lite 2 Adenosine Triphosphate Meter for Biological Content in Fuel (RLU/L)			6	
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.002	
ASTM D 1319 - 10	Aromatics (% vol)		25.0	8.3	
ASTM D 1319 - 10	Olefins (% vol)		5.0	1.1	
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.01	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		153	
	10% Recovered (°C)	157	205	172	
	20% Recovered (°C)	Report Only		180	
	50% Recovered (°C)	168	229	202	
	90% Recovered (°C)	183	262	241	
	End Point (°C)		300	255	
	T50 - T10 (°C)	15		30	
	T90 - T10 (°C)	40		69	
	Residue (% vol)		1.5	1.2	
	Loss (% vol)		1.5	1.0	
ASTM D 93 - 10a	Flash Point (°C)	38	68	48	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.780	
ASTM D 4052 - 09	API Gravity @ 60°F	37.0	51.0	49.8	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-57	
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.4	
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		8.9	
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3	
ASTM D 3338 - 08	Net Heat of Combustion (MJ/kg)	42.8		43.7	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.6	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.5	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		35.0	
ASTM D 976 - 06	Cetane Index, Calculated	Report Only		54	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	1.4	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 1094 - 07	Water Reaction Interface Rating	1b (Max)		1	
ASTM D 2624 - 09	Conductivity				
	Conductivity (pS/m)	150	600	0	X
	Test Temperature (°F)			70	

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2010LA29085002	Date Received:12/22/10 1211 hrs*	Date Sampled: 12/17/2010**
Cust Sample No:HRJ:CLAYTREATED (WITHOUT ADDITIVES)	Date Reported:01/11/11 1047 hrs*	Protocol:FU-AVI-0123

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: HRJ Testing
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Qty Submitted: 1 gal

Method	Test	Min	Max	Result	Fail
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)		0.85	0.73	
ASTM D 7224 - 08	WSIM	Report Only		97	
GC	Gas Chromatographic Analysis			See Below	

Dispositions:
Coordinated with Ben Curtis (PTPT), phone: DSN 785-8050, COM 937-255-8050.
Material fails specification requirements with respect to the test(s) conducted.
GC spectrum is very similar to a lab-prepared JP8/ Tallow-HRJ 50/50 mixture.

Approved By	Date
Miguel Acevedo, Chief \\SIGNED\\	01/11/2011*

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afpet.afth@wpafb.af.mil, afpet.aftt@wpafb.af.mil, anthony.viscomi@wpafb.af.mil, david.craycroft@wpafb.af.mil, kenneth.weller@wpafb.af.mil, michael.thiede@wpafb.af.mil, miguel.acevedo@wpafb.af.mil, timothy.mudry@wpafb.af.mil

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2010LA29085001   Date Received:12/22/10 1211 hrs*   Date Sampled: 12/17/2010**
Cust Sample No:HRJ/JP8 WITH ADDITIVES   Date Reported:01/11/11 1045 hrs*   Protocol:FU-AVI-0123

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: HRJ Testing
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Qty Submitted: 2 gal

Method	Test	Min	Max	Result
ATP	Hy-Lite 2 Adenosine Triphosphate Meter for Biological Content in Fuel (RLU/L)			36
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.003
ASTM D 1319 - 10	Aromatics (% vol)		25.0	8.1
ASTM D 1319 - 10	Olefins (% vol)		5.0	1.1
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.01
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		154
	10% Recovered (°C)	157	205	172
	20% Recovered (°C)	Report Only		180
	50% Recovered (°C)	168	229	202
	90% Recovered (°C)	183	262	240
	End Point (°C)		300	256
	T50 - T10 (°C)	15		30
	T90 - T10 (°C)	40		68
	Residue (% vol)		1.5	1.2
	Loss (% vol)		1.5	0.8
ASTM D 93 - 10a	Flash Point (°C)	38	68	48
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.780
ASTM D 4052 - 09	API Gravity @ 60°F	37.0	51.0	49.7
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-56
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.3
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		8.9
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3
ASTM D 3338 - 08	Net Heat of Combustion (MJ/kg)	42.8		43.7
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.5
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.5
ASTM D 1322 - 08	Smoke Point (mm)	25.0		34.0
ASTM D 976 - 06	Cetane Index, Calculated	Report Only		54
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	1.2
ASTM D 5452 - 08	Particulate Matter (mg/L)		1.0	0.5
MIL-DTL-83133G	Filtration Time (min)		15	4
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.14
ASTM D 1094 - 07	Water Reaction Interface Rating	1b (Max)		1
ASTM D 2624 - 09	Conductivity			

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2010LA29085001	Date Received:12/22/10 1211 hrs*	Date Sampled: 12/17/2010**
Cust Sample No:HRJ/JP8 WITH ADDITIVES	Date Reported:01/11/11 1045 hrs*	Protocol:FU-AVI-0123

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: HRJ Testing
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Qty Submitted: 2 gal

Method	Test	Min	Max	Result
	Conductivity (pS/m)	150	600	312
	Test Temperature (°F)			70
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)		0.85	0.53
ASTM D 7224 - 08	WSIM	Report Only		62
GC	Gas Chromatographic Analysis			See Below

Dispositions:

Material meets specification requirements with respect to the test(s) conducted.
GC spectrum is very similar to a lab-prepared 50/50 JP-8/Tallow HRJ mixture.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	01/11/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
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Lab Report No:2010LA29086006	Date Received:12/22/10 1242 hrs*	Date Sampled: 12/17/2010**
Cust Sample No:HOUSING SUMP WATER 1.08.07.13.15496.01.401	Date Reported:01/19/11 1501 hrs*	Protocol:IA-UNK-0003

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: Unknown Liquid Identification
Product: Unknown Liquid
Specification: N/A

Source: SWRI test facilities Qty Submitted: 1 gal

Method	Test	Min	Max	Result
SEM/EDS	Scanning Electron Microscopy with Energy-Dispersive X-ray Spectroscopy			See Below
GC/MS	Gas Chromatography (Mass Spectroscopy)	Report Only		See Below
LM	Light Microscopy	Report Only		See Below
NEW	Non-Specific Experimental Analysis	Report Only		See Below

Dispositions:
For information purposes only.
The sample was a gallon of hazy water containing fuel system icing inhibitor and inorganic salts of the elements: calcium, magnesium, sodium, chlorine, oxygen, sulfur, and silicon. ATP reading on the water layer was 2 RLU/L suggesting no biological activity.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	01/19/2011*

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
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Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2010LA29086005
Cust Sample No:WATER SUMP FROM TEST 5 1.08.07.13.15496.01.401

Date Received:12/22/10 1242 hrs*
Date Reported:01/19/11 1500 hrs*

Date Sampled: 12/17/2010**
Protocol:IA-UNK-0003

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: Unknown Liquid Identification
Product: Unknown Liquid
Specification: N/A

Source: SWRI test facilities   Qty Submitted: 1 gal

Method	Test	Min	Max	Result
SEM/EDS	Scanning Electron Microscopy with Energy-Dispersive X-ray Spectroscopy			See Below
FTIR	FTIR - Horizontal Attenuated Total Reflectance (HATR) Accessory	Report Only		See Below
GC/MS	Gas Chromatography (Mass Spectroscopy)	Report Only		See Below
LM	Light Microscopy	Report Only		See Below
NEW	Non-Specific Experimental Analysis	Report Only		See Below

Dispositions:
For information purposes only.
The sample formed two layers, top and bottom. The top straw colored layer was about 500 mL of a mixture of hydrocarbons consistent with aviation fuels. The hazy bottom layer was about 3 liters of a mixture of water and fuel system icing inhibitor. The water layer contained several salts involving the elements: calcium, magnesium, sodium, chlorine, oxygen, sulfur, and silicon. ATP reading on the water layer was 2 RLU/L suggesting no biological activity.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	01/19/2011*

This report was electronically delivered to:
afpet.afth@wpafb.af.mil, benet.curtis@wpafb.af.mil, david.craycroft@wpafb.af.mil, gordon.walker@wpafb.af.mil, miguel.acevedo@wpafb.af.mil, paul.twehues2@wpafb.af.mil, thomas.harmon@wpafb.af.mil, timothy.mudry@wpafb.af.mil

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2010LA29086003   Date Received:12/22/10 1242 hrs*   Date Sampled: 12/17/2010**
Cust Sample No:PLUS 100   Date Reported:01/13/11 1430 hrs*   Protocol:IA-UNK-0003
1.08.07.13.15496.01.401

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: Unknown Liquid Identification
Product: Unknown Liquid
Specification: N/A

Source: SWRI test facilities   Qty Submitted: 30 mL

Method	Test	Min	Max	Result
GC/MS	Gas Chromatography (Mass Spectroscopy)	Report Only		See Below

Dispositions:
For information purposes only.
Various substitued napthalenes were the volatiles detected in this sample. Sample appears to have the GC/MS spectrum of a typical +100 sample.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	01/13/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2010LA29086002	Date Received:12/22/10 1242 hrs*	Date Sampled: 12/17/2010**
Cust Sample No:FSII 1.08.07.13.15496.01.401	Date Reported:01/13/11 1429 hrs*	Protocol:IA-UNK-0003

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: Unknown Liquid Identification
Product: Unknown Liquid
Specification: N/A

Source: SWRI test facilities Qty Submitted: 30 mL

Method	Test	Min	Max	Result
GC/MS	Gas Chromatography (Mass Spectroscopy)	Report Only		See Below

Dispositions:
For information purposes only.
Diethylene Glycol Monomethyl Ether (DiEGME) was the only volatile compound detected in this sample. Sample appears to be a typical FSII.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	01/13/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2010LA29086007	Date Received:12/22/10 1242 hrs*	Date Sampled: 12/17/2010**
Cust Sample No:USED FUEL FILTER 1.08.07.13.15496.01.401	Date Reported:01/20/11 1827 hrs*	Protocol:IA-UNK-0012

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: Unknown Filter Analysis
Product: Filter
Specification: N/A

Source: SWRI Test Facilities   Qty Submitted: 2 filters

Method	Test	Min	Max	Result
FTIR	FTIR - Horizontal Attenuated Total Reflectance (HATR) Accessory	Report Only		See Below
LM	Light Microscopy	Report Only		See Below
NEW	Non-Specific Experimental Analysis	Report Only		See Below
SEM/EDS	Scanning Electron Microscopy with Energy-Dispersive X-ray Spectroscopy	Report Only		See Below

Dispositions:

For information purposes only.
Two coalescer filters were examined. One filter was marked with I-614A4TB WO#88460 12/10/09. The other filter was marked with I-61487TB WO#102713 09-17-10. Both filters showed some light brown coloring on the outer sock. The white cushion layer under the sock was unremarkable for both filters. The bolt end cap of the A4 series filter could be removed without much effort. The threads of the A4 series filter contained a clear material identified as a silicon-based grease. The threads of the 87 series filter were dry and clean. Both filters had micronic filters that contained a fine mixture of sand and iron oxides. The micronic filter on the 87 series filter was uniformly coated with the solids mixture. However, the micron filter of the A4 series filter appeared to concentrate the solids mixture toward the bolt end cap.

Approved By	Date
Miguel Acevedo, Chief \\SIGNED\\	01/20/2011*

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Appendix H

Phase II Single Element Test Data

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TEST ONE (JP-8 series)

Test Specification: API 1581 5th Edition | Unadditized Fuel | **Date** 04/11/11

Vessel: Horizontal single element | **Filter/Coalescer:** TC-C0162 (CM14SB-5) | **Separator:** SM-07FF-5 | **Type**:

Additive Addition	**Model**	**Number**	**Model**	**Number**
Category:				
Tank Volume **Gallon**				
11,118 Gal.				
Note:				
Mixing Time (min):				

Element Conditioning: ☐-In-Situ | **Time (min)**

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m)	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	3.7	000				M-1	5 gal	2	72	MSEPA= 99
Water 0.01%	5	0	25.9	3.6	000	9.8	0.0						
	10	5	25.6	3.8		9.8	0.0						
	15	10 s/s	25.9	3.9		9.8	0.0						
	25	20 s/s	25.9	4.5		9.8	0.0						
	35	30 s/s	25.9	5.5	000	9.8	0.0					72	

TEST ONE

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	5.5	000			19 mg/l				72	
	50	15	25.9	5.7				19	S-1	0.02	51		
		15 s/s	25.9	5.7				19	S-2	0.02	51		
	65	30	25.9	5.8	000			19	S-3	0.05	51	72	
		30 s/s	25.9	5.9				19	S-4	0.02	51		
	80	45	25.9	5.7				19	S-5	0.03	51		
		45 s/s	25.9	5.7				19	S-6	0.01	51		
		50	25.9	5.7				19					
	95	60	25.9	5.9	000			19	S-7	0.03	51	72	
		60 s/s	25.9	6.0				19	S-8	0.00	51		
	110	75	25.9	6.5				19	S-9	0.03	51		
		75 s/s	25.9	6.5				19	S-10	0.02	51		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST ONE

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	6.5	000	9.8	0.0					73	
	112	2	25.9	6.3		9.8	0.0						
	115	5	25.9	6.0		9.8	0.0						
	125	15	25.9	5.9		9.8	0.0						
	140	30 s/s	25.9	7.1	000	9.8	0.0					73	
	155	45	25.9	7.1		9.8	0.0						
	170	60 s/s	25.9	7.2	000	9.8	0.5						
	185	75	25.9	7.3		9.8	0.0						
	200	90 s/s	25.9	7.4		9.8	0.5					73	
	215	105	25.9	7.5	000	9.8	0.0						
	230	120 s/s	25.9	7.6		9.8	0.5						
	245	135	25.9	7.7		9.8	0.0						
	260	150 s/s	25.9	7.8		9.8	0.0						
Water Coalescence Test 3%	260	0	25.9	7.4	000	.78 gal	0.0					74	
	262	2	25.9	11.9		.78	0.0						¼ " drops
	265	5	25.9	12.5		.78	0.5						
	270	10 s/s	25.9	13.3	000	.78	0.0						
	280	20 s/s	25.9	14.6		.78	0.0						
	290	30	25.9	15.6	000	.78	0.0					74	

TEST TWO (JP-8 series)

Test Specification: API 1581 5th Edition					SDA Only, Fuel							**Date** 04/12/11	
Vessel: Horizontal single element				**Filter/Coalescer:** TC-C0162 (CM14SB-5)				**Separator:** SM-07FF-5				**Type**:	
Additive Addition				**Model**	**Number**			**Model**	**Number**				
Category:													
Tank Volume	**Gallon**												
11,118	Gal.						**Stadis**	2.0 mg/l	84.17	940			
Note:													
	Mixing Time (min):												
Element Conditioning:		☐-In-Situ			**Time (min)**								
Phase	**Cum. Time (min)**	0	**Fuel Flow Rate (gpm)**	**ΔP (psi)**	**K (Ps/m)**	**Water Flow Rate ☑ml/min**	**Water Conc. (ppm)**	**Solids Rate ☐mg/l ☐mg/gal**	**Filter Sample ID**	**Sample Size**	**Fibers per gallon**	**Temp. ☑°F**	**Notes/Comments**
Start-up	0	0	25.9	3.7	051				M-1	5 gal	1	74	
Water 0.01%	5	0	25.9	3.7	773	9.8	0.0						
	10	5	25.6	3.9		9.8	0.0						
	15	10 s/s	25.9	4.1		9.8	0.0						
	25	20 s/s	25.9	4.2		9.8	0.0						
	35	30 s/s	25.9	4.2	818	9.8	0.0					74	

TEST TWO

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	4.3	810			19 mg/l				74	
	50	15	25.9	4.2				19	S-1	0.00	51		
		15 s/s	25.9	4.3				19	S-2	0.05	51		
	65	30	25.9	4.6	765			19	S-3	0.03	51	74	
		30 s/s	25.9	4.7				19	S-4	0.04	51		
	80	45	25.9	5.2				19	S-5	0.04	51		
		45 s/s	25.9	5.3				19	S-6	0.03	51		
		50	25.9	5.5				19					
	95	60	25.9	6.1	804			19	S-7	0.02	51	74	
		60 s/s	25.9	6.1				19	S-8	0.02	51		
	110	75	25.9	7.3				19	S-9	0.01	51		
		75 s/s	25.9	7.3				19	S-10	0.05	51		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST TWO

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	8.0	802	9.8	0.0					74	
	112	2	25.9	8.1		9.8	0.0						
	115	5	25.9	8.2		9.8	0.0						
	125	15	25.9	8.3		9.8	0.0						
	140	30 s/s	25.9	8.4	866	9.8	0.0					74	
	155	45	25.9	8.1		9.8	0.0						
	170	60 s/s	25.9	8.3	853	9.8	0.5						
	185	75	25.9	8.2		9.8	0.5						
	200	90 s/s	25.9	8.3		9.8	0.5					74	
	215	105	25.9	8.3	820	9.8	0.5						
	230	120 s/s	25.9	8.4		9.8	1.0						
	245	135	25.9	8.4		9.8	0.5						
	260	150 s/s	25.9	8.6		9.8	0.5						
Water Coalescence Test 3%	260	0	25.9	8.5	947	.78 gal	---					74	
	262	2	25.9	15.9		.78	1.0						¼ " drops
	265	5	25.9	17.1		.78	1.0						
	270	10 s/s	25.9	18.6	975	.78	1.0						
	280	20 s/s	25.9	18.8		.78	0.5						
	290	30	25.9	20.4	989	.78	0.5					74	

TEST THREE (JP-8 series)

Test Specification: API 1581 5th Edition	FSII Only, Fuel		**Date** 04/14/11
Vessel: Horizontal single element	**Filter/Coalescer:** TC-C0162 (CM14SB-5)	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:				
Tank Volume	**Gallon**			
11,058	Gal.	**FSII**	0.15%	16.6 / 000
Note:				
Mixing Time (min):			20	
Element Conditioning:	☐-In-Situ	**Time (min)**		

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m)	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	4.1	000				M-1	5 gal	1	72	MSEPA= 99
Water 0.01%	5	0	25.9	4.1	000	9.8	0.0						
	10	5	25.6	4.3		9.8	0.0						
	15	10 s/s	25.9	4.5		9.8	0.0						
	25	20 s/s	25.9	4.8		9.8	0.0						
	35	30 s/s	25.9	5.8	000	9.8	0.0					73	

TEST THREE

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	5.8	000			19 mg/l				73	
	50	15	25.9	5.8				19	S-1	0.04	51		
		15 s/s	25.9	5.8				19	S-2	0.03	51		
	65	30	25.9	5.9	000			19	S-3	0.04	51	73	
		30 s/s	25.9	5.9				19	S-4	0.04	51		
	80	45	25.9	6.2				19	S-5	0.07	51		
		45 s/s	25.9	6.3				19	S-6	0.01	51		
		50	25.9	6.4				19					
	95	60	25.9	6.8	000			19	S-7	0.02	51	73	
		60 s/s	25.9	6.9				19	S-8	0.01	51		
	110	75	25.9	7.8				19	S-9	0.04	51		
		75 s/s	25.9	7.9				19	S-10	0.01	51		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST THREE

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	8.6	000	9.8	0.0					73	
	112	2	25.9	8.4		9.8	0.0						
	115	5	25.9	8.4		9.8	0.0						
	125	15	25.9	8.8		9.8	0.0						
	140	30 s/s	25.9	9.4	000	9.8	0.0					73	
	155	45	25.9	9.5		9.8	0.0						
	170	60 s/s	25.9	9.6	000	9.8	1.0						
	185	75	25.9	9.6		9.8	0.0						
	200	90 s/s	25.9	9.9		9.8	1.0					73	
	215	105	25.9	10.1	000	9.8	0.5						
	230	120 s/s	25.9	10.2		9.8	1.0						
	245	135	25.9	10.3		9.8	1.0						
	260	150 s/s	25.9	10.4		9.8	1.0						
Water Coalescence Test 3%	260	0	25.9	9.4	000	.78 gal	0.0					73	
	262	2	25.9	15.4		.78	1.0						1/8 – 1/4“ drops
	265	5	25.9	16.9		.78	0.0						
	270	10 s/s	25.9	19.0	000	.78	0.0						
	280	20 s/s	25.9	23.9		.78	0.0						
	290	30	25.9	27.1	000	.78	1.0					73	

TEST FOUR (JP-8 series)

Test Specification: API 1581 5th Edition	CI/LI Only, Fuel		**Date** 04/18/11
Vessel: Horizontal single element	**Filter/Coalescer:** TC-C0162 (CM14SB-5)	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:								
Tank Volume	**Gallon**							
11,058	Gal.			**CI/LI**	15 mg/l	628	004	
Note:								

Mixing Time (min): 20

Element Conditioning: ☐-In-Situ **Time (min)**

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m)	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sampl e Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	4.0	003				M-1	5 gal	2	72	MSEPA= 97
Water 0.01%	5	0	25.9	4.0	003	9.8	0.0						
	10	5	25.6	4.2		9.8	0.0.						
	15	10 s/s	25.9	4.4		9.8	0.0						
	25	20 s/s	25.9	5.0		9.8	0.0						
	35	30 s/s	25.9	5.4	003	9.8	0.0					72	

TEST FOUR

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	5.4	003			19 mg/l				72	
	50	15	25.9	5.4				19	S-1	0.03	41		
		15 s/s	25.9	5.4				19	S-2	0.03	41		
	65	30	25.9	5.7	003			19	S-3	0.01	41	73	
		30 s/s	25.9	5.8				19	S-4	0.01	41		
	80	45	25.9	6.4				19	S-5	0.00	41		
		45 s/s	25.9	6.5				19	S-6	0.01	41		
		50	25.9	6.8				19					
	95	60	25.9	7.4	002			19	S-7	0.01	41	73	
		60 s/s	25.9	7.4				19	S-8	0.03	41		
	110	75	25.9	9.2				19	S-9	0.02	41		
		75 s/s	25.9	9.3				19	S-10	0.02	41		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST FOUR

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑ºF	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	9.7	001	9.8	0.0					73	
	112	2	25.9	9.7		9.8	0.0						
	115	5	25.9	9.8		9.8	0.0						
	125	15	25.9	10.8		9.8	0.0						
	140	30 s/s	25.9	10.9	003	9.8	0.0					73	
	155	45	25.9	11.2		9.8	0.0						
	170	60 s/s	25.9	11.4	002	9.8	0.0						
	185	75	25.9	11.5		9.8	0.0						
	200	90 s/s	25.9	11.6		9.8	0.0					73	
	215	105	25.9	11.7	003	9.8	0.0						
	230	120 s/s	25.9	11.9		9.8	0.0						
	245	135	25.9	12.0		9.8	0.5						
	260	150 s/s	25.9	12.4		9.8	0.5						
Water Coalescence Test 3%	260	0	25.9	10.6	003	.78 gal	0.0					74	
	262	2	25.9	22.4		.78	0.5						1/16 – 1/4 " drops
	265	5	25.9	25.0		.78	0.5						
	270	10 s/s	25.9	27.1	001	.78	0.5						
	280	20 s/s	25.9	31.6		.78	0.5						
	290	30	25.9	33.3	001	.78	0.5					74	

TEST FIVE (JP-8 series)

Test Specification: API 1581 5th Edition	SDA and FSII Only, Fuel				**Date** 04/19/11
Vessel: Horizontal single element	**Filter/Coalescer:** TC-C0162 (CM14SB-5)		**Separator:** SM-07FF-5		**Type**:
Additive Addition	**Model**	**Number**	**Model**	**Number**	

Category:					
Tank Volume	**Gallon**				
10,939	Gal.	**SDA**	2.0 mg/l	82.8	918
Note:		**FSII**	0.15%	16.4	980
Mixing Time (min):				20	
Element Conditioning:	☐-In-Situ	**Time (min)**			

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m)	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	3.7	052				M-1	5 gal	3	73	MSEPA= 72
Water 0.01%	5	0	25.9	3.7	560	9.8	0.0						
	10	5	25.6	3.9		9.8	0.0						
	15	10 s/s	25.9	4.1		9.8	0.0						
	25	20 s/s	25.9	4.3		9.8	0.0						
	35	30 s/s	25.9	4.4	0.0	9.8						73	

TEST FIVE

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	4.4	834			19 mg/l				73	
	50	15	25.9	4.2				19	S-1	0.01	41		
		15 s/s	25.9	4.2				19	S-2	0.02	41		
	65	30	25.9	4.5	635			19	S-3	0.06	41	73	
		30 s/s	25.9	4.6				19	S-4	0.04	41		
	80	45	25.9	5.2				19	S-5	0.04	41		
		45 s/s	25.9	5.3				19	S-6	0.04	41		
		50	25.9	5.6				19					
	95	60	25.9	6.2	582			19	S-7	0.02	41	73	
		60 s/s	25.9	6.2				19	S-8	0.05	41		
	110	75	25.9	7.4				19	S-9	0.02	41		
		75 s/s	25.9	7.4				19	S-10	0.00	41		

[a] s/s: sample taken immediately after conclusion of stop/start

TEST FIVE

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	7.7	577	9.8	0.0					73	
	112	2	25.9	8.1		9.8	0.0						
	115	5	25.9	8.4		9.8	0.0						
	125	15	25.9	8.7		9.8	0.0						
	140	30 s/s	25.9	9.1	888	9.8	0.5					73	
	155	45	25.9	9.2		9.8	0.5						
	170	60 s/s	25.9	9.3	947	9.8	0.5						
	185	75	25.9	9.5		9.8	0.5						
	200	90 s/s	25.9	9.7		9.8	0.5					74	
	215	105	25.9	9.8	960	9.8	0.5						
	230	120 s/s	25.9	10.0		9.8	1.0						
	245	135	25.9	10.2		9.8	0.5						
	260	150 s/s	25.9	10.3		9.8	0.5						
Water Coalescence Test 3%	260	0	25.9	8.0	994	.78 gal	0.0					74	
	262	2	25.9	16.4		.78	0.0						1/8 – 1/4 “ drops
	265	5	25.9	16.9		.78	0.5						
	270	10 s/s	25.9	17.7	1042	.78	0.5						
	280	20 s/s	25.9	18.3		.78	0.5						
	290	30	25.9	18.7	1150	.78	0.5					74	

TEST SIX (JP-8 series)

Test Specification: API 1581 5th Edition	SDA and CI/LI Only, Fuel		**Date** 04/21/11
Vessel: Horizontal single element	**Filter/Coalescer:** TC-C0162 (CM14SB-5)	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:

Tank Volume	**Gallon**				
11,058	Gal.	**SDA**	2.0 mg/l	83.7	945
Note:		**CI/LI**	15 mg/l	628	983

Mixing Time (min): 20

Element Conditioning: ☐-In-Situ **Time (min)**

Phase	Cum. Time (min)	Time (min	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m)	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	4.0	512				M-1	5 gal	1	73	MSEPA= 42
Water 0.01%	5	0	25.9	4.0	614	9.8	0.0						
	10	5	25.6	4.2		9.8	0.0						
	15	10 s/s	25.9	4.4		9.8	0.0						
	25	20 s/s	25.9	4.9		9.8	0.0						
	35	30 s/s	25.9	5.2	768	9.8	0.0					72	

TEST SIX

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	5.3	654			19 mg/l				72	
	50	15	25.9	5.3				19	S-1	0.03	41		
		15 s/s	25.9	5.4				19	S-2	0.07	41		
	65	30	25.9	5.6	739			19	S-3	0.02	41	73	
		30 s/s	25.9	5.6				19	S-4	0.01	41		
	80	45	25.9	6.3				19	S-5	0.02	41		
		45 s/s	25.9	6.3				19	S-6	0.01	41		
		50	25.9	6.5				19					
	95	60	25.9	7.2	736			19	S-7	0.03	41	73	
		60 s/s	25.9	7.2				19	S-8	0.03	41		
	110	75	25.9	8.9				19	S-9	0.02	41		
		75 s/s	25.9	9.0				19	S-10	0.01	41		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST SIX

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	10.1	735	9.8	0.0					72	
	112	2	25.9	10.3		9.8	0.0						
	115	5	25.9	10.5		9.8	0.0						
	125	15	25.9	11.0		9.8	0.0						
	140	30 s/s	25.9	11.4	828	9.8	0.0					72	
	155	45	25.9	11.4		9.8	0.0						
	170	60 s/s	25.9	11.9	800	9.8	0.0						
	185	75	25.9	12.0		9.8	0.0						
	200	90 s/s	25.9	12.4		9.8	0.5					72	
	215	105	25.9	12.4	825	9.8	0.5						
	230	120 s/s	25.9	12.8		9.8	0.5						
	245	135	25.9	12.9		9.8	0.5						
	260	150 s/s	25.9	13.1		9.8	1.0						
Water Coalescence Test 3%	260	0	25.9	11.7	825	.78 gal	0.0					72	
	262	2	25.9	22.7		.78	0.5						1/16 – 1/4 " drops
	265	5	25.9	26.2		.78	0.0						
	270	10 s/s	25.9	29.4	963	.78	1.0						
	280	20 s/s	25.9	33.4		.78	0.5						
	290	30	25.9	36.4	932	.78	0.5					72	

TEST SEVEN (JP-8 series)

Test Specification: API 1581 5th Edition	CI/LI and FSII Only, Fuel		**Date** 04/25/11
Vessel: Horizontal single element	**Filter/Coalescer:** TC-C0162 (CM14SB-5)	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:					
Tank Volume	**Gallon**				
10,899	Gal.	**FSII**	0.15%	16.35	002
Note:		**CI/LI**	15 mg/l	619	003
Mixing Time (min):				20	
Element Conditioning:	☐-In-Situ	**Time (min)**			

Phase	Cum. Time (min)	Time (min	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m)	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	4.0	002				M-1	5 gal	2	70	MSEPA= 90
Water 0.01%	5	0	25.9	4.0	002	9.8	0.0						
	10	5	25.6	4.2		9.8	0.0						
	15	10 s/s	25.9	4.5		9.8	0.0						
	25	20 s/s	25.9	5.0		9.8	0.0						
	35	30 s/s	25.9	5.2	003	9.8	0.5					71	

TEST SEVEN

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	5.2	003			19 mg/l				71	
	50	15	25.9	5.0				19	S-1	0.02	4l		
		15 s/s	25.9	5.0				19	S-2	0.06	4l		
	65	30	25.9	5.1	003			19	S-3	0.03	4l	72	
		30 s/s	25.9	5.1				19	S-4	0.02	4l		
	80	45	25.9	5.7				19	S-5	0.09	4l		
		45 s/s	25.9	5.7				19	S-6	0.02	4l		
		50	25.9	6.0				19					
	95	60	25.9	6.4	002			19	S-7	0.01	4l	72	
		60 s/s	25.9	6.4				19	S-8	0.05	4l		
	110	75	25.9	7.6				19	S-9	0.02	4l		
		75 s/s	25.9	7.6				19	S-10	0.05	4l		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST SEVEN

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	7.8	003	9.8	0.0					72	
	112	2	25.9	8.0		9.8	0.0						
	115	5	25.9	8.0		9.8	0.0						
	125	15	25.9	8.7		9.8	0.0						
	140	30 s/s	25.9	9.1	004	9.8	0.5					72	
	155	45	25.9	9.2		9.8	0.5						
	170	60 s/s	25.9	9.3	005	9.8	0.5						
	185	75	25.9	9.5		9.8	0.5						
	200	90 s/s	25.9	9.6		9.8	1.0					73	
	215	105	25.9	9.8	007	9.8	1.0						
	230	120 s/s	25.9	9.9		9.8	1.0						
	245	135	25.9	10.0		9.8	1.0						
	260	150 s/s	25.9	10.0		9.8	1.0						
Water Coalescence Test 3%	260	0	25.9	8.8	009	.78 gal	0.0					73	
	262	2	25.9	14.6		.78	0.0						1/8 – 1/4 " drops
	265	5	25.9	16.6		.78	0.0						
	270	10 s/s	25.9	19.3	004	.78	0.5						
	280	20 s/s	25.9	23.6		.78	0.0						
	290	30	25.9	26.9	004	.78	0.5					73	

TEST EIGHT (JP-8 series)

Test Specification: API 1581 5th Edition	SDA, CI/LI and FSII Only, Fuel				**Date** 04/27/11
Vessel: Horizontal single element	**Filter/Coalescer:** TC-C0162 (CM14SB-5)		**Separator:** SM-07FF-5		**Type**:
Additive Addition	**Model**	**Number**	**Model**	**Number**	

Category:				
Tank Volume	**Gallon**			
11,098	Gal.			
Note:				
	SDA	2.0 mg/l	84.0	923
	FSII	0.15%	16.6	998
	CI/LI	15 mg/l	630	1033
Mixing Time (min):			20	
Element Conditioning: ☐-In-Situ	**Time (min)**			

Phase	Cum. Time (min)	Time (min	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m)	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sampl e Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	3.7	114				M-1	5 gal	1	74	MSEPA= 00
Water 0.01%	5	0	25.9	3.7	342	9.8	0.0						
	10	5	25.6	3.9		9.8	0.0						
	15	10 s/s	25.9	4.2		9.8	0.0						
	25	20 s/s	25.9	4.4		9.8	0.0						
	35	30 s/s	25.9	4.7	526	9.8	0.0					74	

TEST EIGHT

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	4.7	514			19 mg/l				74	
	50	15	25.9	4.8				19	S-1	0.05	41		
		15 s/s	25.9	4.8				19	S-2	0.02	41		
	65	30	25.9	5.1	610			19	S-3	0.03	41	74	
		30 s/s	25.9	5.1				19	S-4	0.02	41		
	80	45	25.9	5.8				19	S-5	0.03	41		
		45 s/s	25.9	5.8				19	S-6	0.02	41		
		50	25.9	6.1				19					
	95	60	25.9	6.6	531			19	S-7	0.05	41	75	
		60 s/s	25.9	6.6				19	S-8	0.01	41		
	110	75	25.9	8.2				19	S-9	0.01	41		
		75 s/s	25.9	8.3				19	S-10	0.04	41		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST EIGHT

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	8.7	5.8	9.8	0.0					75	
	112	2	25.9	9.4		9.8	0.0						
	115	5	25.9	10.7		9.8	0.0						
	125	15	25.9	11.2		9.8	0.5						
	140	30 s/s	25.9	11.8	813	9.8	0.5					75	
	155	45	25.9	12.8		9.8	0.5						
	170	60 s/s	25.9	13.4	894	9.8	0.5						
	185	75	25.9	14.4		9.8	0.5						
	200	90 s/s	25.9	14.7		9.8	0.5					75	
	215	105	25.9	15.6	854	9.8	0.5						
	230	120 s/s	25.9	16.7		9.8	0.5						
	245	135	25.9	17.0		9.8	0.5						
	260	150 s/s	25.9	17.8		9.8	1.0						
Water Coalescence Test 3%	260	0	25.9	12.4	873	.78 gal	0.0					75	
	262	2	25.9	24.7		.78	0.0						1/8 – 1/4 " drops
	265	5	25.9	25.8		.78	0.5						
	270	10 s/s	25.9	27.5	1043	.78	0.5						
	280	20 s/s	25.9	29.5		.78	0.5						
	290	30	25.9	31.0	1097	.78	0.5					75	

TEST NINE (JP-8 series)

Test Specification: API 1581 5th Edition	SDA, CI/LI and FSII Only, 50/50 A1&A3 test dust		**Date** 04/29/11
Vessel: Horizontal single element	**Filter/Coalescer:** TC-C0162 (CM14SB-5)	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:

Tank Volume	Gallon
10,919	Gal.

Note:

	Conc.	Amt Added	k (ps/m)
SDA	2.0 mg/l	82.7	875
FSII	0.15%	16.4	984
CI/LI	15 mg/l	620	1032

Mixing Time (min): 20

Element Conditioning: ☐-In-Situ **Time (min)**

Phase	Cum. Time (min)	Time (min	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m)	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sampl e Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	3.8	104				M-1	5 gal	2	73	MSEPA= 38
Water 0.01%	5	0	25.9	3.8	375	9.8	0.0						
	10	5	25.6	4.1		9.8	0.0						
	15	10 s/s	25.9	4.3		9.8	0.0						
	25	20 s/s	25.9	4.6		9.8	0.0						
	35	30 s/s	25.9	4.7	401	9.8	0.0					73	

TEST NINE

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	4.7	502			19 mg/l				73	
	50	15	25.9	4.7				19	S-1	0.01	41		
		15 s/s	25.9	4.8				19	S-2	0.06	41		
	65	30	25.9	5.2	610			19	S-3	0.06	41	73	
		30 s/s	25.9	5.2				19	S-4	0.05	41		
	80	45	25.9	5.6				19	S-5	0.07	41		
		45 s/s	25.9	5.6				19	S-6	0.01	41		
		50	25.9	5.7				19					
	95	60	25.9	6.2	567			19	S-7	0.04	41	73	
		60 s/s	25.9	6.3				19	S-8	0.04	41		
	110	75	25.9	7.4				19	S-9	0.02	41		
		75 s/s	25.9	7.5				19	S-10	0.03	41		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST NINE

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	7.7	577	9.8	0.0					73	
	112	2	25.9	8.4		9.8	0.0						
	115	5	25.9	8.8		9.8	0.0						
	125	15	25.9	9.3		9.8	0.0						
	140	30 s/s	25.9	9.9	686	9.8	0.5					73	
	155	45	25.9	10.5		9.8	0.5						
	170	60 s/s	25.9	10.9	808	9.8	0.5						
	185	75	25.9	11.7		9.8	0.5						
	200	90 s/s	25.9	12.7		9.8	0.5					73	
	215	105	25.9	13.2	879	9.8	0.5						
	230	120 s/s	25.9	13.9		9.8	0.5						
	245	135	25.9	14.2		9.8	0.5						
	260	150 s/s	25.9	15.0		9.8	0.5						
Water Coalescence Test 0.5%	260	0	25.9	11.3	926	.78 gal	0.0					73	
	262	2	25.9	16.8		.78	0.0						1/16–1/8” and very small
	265	5	25.9	19.9		.78	0.0						Droplets.
	270	10 s/s	25.9	21.8	989	.78	0.5						
	280	20 s/s	25.9	24.5		.78	0.5						
	290	30	25.9	26.3	1016	.78	0.5					74	

TEST TEN (JP-8 series)

Test Specification: API 1581 5th Edition	DSA, FSII and CI/LI		**Date** 05/03/11
Vessel: Horizontal	**Filter/Coalescer:** TC-C0162 CM14SB-5	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:				
Tank Volume **Gallon**		Conc.	Amt. Added	k (ps/m)
10,899 Gal.	**DSA**	2.0 mg/l	82.5	812
Note:	**FSII**	0.15%	16.35	965
	CI/LI	15 mg/l	619	1048
Mixing Time (min):		20 min		

Element Conditioning: ☐-In-Situ **Time (min)**

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m) effluent	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	34.0	4.9	109				M-10	5 gal	1	70	MSEPA= 00
Water 0.01%	5	0	34.0	5.0	419	12.9	0.0						
	10	5	34.0	5.4		12.9	0.0						
	15	10 s/s	34.0	5.6		12.9	0.0						
	25	20 s/s	34.0	6.0		12.9	0.0						
	35	30 s/s	34.0	6.2	630	12.9	0.0						

TEST TEN

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	34.0	6.1	647			19 mg/l				70	
	50	15	34.0	6.4				19	S-1	0.02	4L		
		15 s/s	34.0	6.4				19	S-2	0.01	4L		
	65	30	34.0	6.9	736			19	S-3	0.04	4L	70	
		30 s/s	34.0	7.0				19	S-4	0.01	4L		
	80	45	34.0	7.8				19	S-5	0.01	4L		
		45 s/s	34.0	7.8				19	S-6	0.02	4L		
		50	34.0	8.2				19					
	95	60	34.0	9.4	711			19	S-7	0.01	4L	70	
		60 s/s	34.0	9.4				19	S-8	0.01	4L		
	110	75	34.0	12.6				19	S-9	0.02	4L		
		75 s/s	34.0	12.6				19	S-10	0.06	4L		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST TEN

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑ºF	Notes/Comments
Water Coalescence Test – 0.01%	110	0	34.0	13.7	633	12.9	0.0					70	
	112	2	34.0	18.9		12.9	0.0						
	115	5	34.0	21.6		12.9	0.0						
	125	15	34.0	24.4		12.9	0.0						
	140	30 s/s	34.0	26.8	863	12.9	0.0					70	
	155	45	34.0	28.4		12.9	0.0						
	170	60 s/s	34.0	30.2	934	12.9	0.5						
	185	75	34.0	30.6		12.9	0.0						
	200	90 s/s	34.0	32.3		12.9	0.5					71	
	215	105	34.0	32.2	952	12.9	0.5						
	230	120 s/s	34.0	33.3		12.9	0.5						
	245	135	34.0	32.6		12.9	0.5						
	260	150 s/s	34.0	33.6		12.9	0.5						
Water Coalescence Test 3%	260	0	34.0	23.8	802	1.02 gal	0.0					71	
	262	2	34.0	38.8		1.02	0.5						1/8–1/4"' drops, many fines
	265	5	34.0	42.0		1.02	0.5						
	270	10 s/s	34.0	45.9	1004	1.02	0.5						
	280	29 s/s	34.0	48.2		1.02	0.5						
	290	30	34.0	51.3	1061	1.02	0.5					71	

TEST ONE

Test Specification: API 1581 5th Edition	Unadditized 50/50 Blend Fuel		**Date** 03/10/11
Vessel: Horizontal single element	**Filter/Coalescer:** TC-C0162 (CM14SB-5)	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	
Category:			
Tank Volume / **Gallon**			
10,464 Gal.			
Note:			
Mixing Time (min):			
Element Conditioning: ☐-In-Situ	**Time (min)**		

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m)	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	4.0	00				M-1	5 gal	2	71	MSEPA= 99
Water 0.01%	5	0	25.9	4.0	00/00	9.8	0.0						
	10	5	25.6	4.0		9.8	0.0						
	15	10 s/s	25.9	4.0		9.8	1.0						
	25	20 s/s	25.9	4.1		9.8	0.0						
	35	30 s/s	25.9	4.2	00/00	9.8	0.0					70	

TEST ONE

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	4.1	00/00			19 mg/l				70	
	50	15	25.9	4.6				19	S-1	0.03	51		
		15 s/s	25.9	4.7				19	S-2	0.05	51		
	65	30	25.9	4.6	00/00			19	S-3	0.08	51	70	
		30 s/s	25.9	4.7				19	S-4	0.02	51		
	80	45	25.9	4.8				19	S-5	0.02	51		
		45 s/s	25.9	4.8				19	S-6	0.00	51		
		50	25.9	4.8				19					
	95	60	25.9	5.1	00/00			19	S-7	0.02	51	70	
		60 s/s	25.9	5.2				19	S-8	0.05	51		
	110	75	25.9	5.6				19	S-9	0.05	51		
		75 s/s	25.9	6.5				19	S-10	0.04	51		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST ONE

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	6.5	00	9.8	0.0					70	
	112	2	25.9	7.0		9.8	0.0						
	115	5	25.9	7.1		9.8	0.0						
	125	15	25.9	7.9		9.8	0.0						
	140	30 s/s	25.9	8.5	00	9.8	0.0					70	
	155	45	25.9	9.0		9.8	0.0						
	170	60 s/s	25.9	9.4	00	9.8	0.0						
	185	75	25.9	9.6		9.8	0.0						
	200	90 s/s	25.9	9.8		9.8	0.0					70	
	215	105	25.9	9.9	00	9.8	0.0						
	230	120 s/s	25.9	10.0		9.8	0.0						
	245	135	25.9	10.2		9.8	0.0						
	260	150 s/s	25.9	10.3		9.8	0.0						
Water Coalescence Test 3%	260	0	25.9	9.9	00	.78 gal	-----					70	
	262	2	25.9	13.3		.78	0.0						¼” drops
	265	5	25.9	14.6		.78	0.0						
	270	10 s/s	25.9	15.9	00	.78	0.0						
	280	20 s/s	25.9	16.8		.78	0.0						
	290	30	25.9	18.4	00	.78	0.0					69	

TEST TWO

Test Specification: API 1581 5th Edition	50/50 Blend Fuel with Stadis only		**Date** 03/11/11
Vessel: Horizontal	**Filter/Coalescer:** TC-C0162 CM14SB-5	**Separator:** SM-07FF-5	**Type**:

Additive Addition	Model	Number	Model	Number

Category:

Tank Volume	Gallon		Conc.	Amt. Added	k (ps/m)
10,434	Gal.	**Stadis**	2 mg/l	79.0 g	730

Note:

Mixing Time (min): 20 min

Element Conditioning: ☐-In-Situ   **Time (min)**

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m) effluent	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	3.9	270				M-2	5 gal	3	70	MSEPA= 86
Water 0.01%	5	0	25.9	4.0	588	9.8	0.0						
	10	5	25.6	4.1		9.8	0.0						
	15	10 s/s	25.9	4.1		9.8	0.0						
	25	20 s/s	25.9	4.3		9.8	0.0						
	35	30 s/s	25.9	4.4	599	9.8	0.0					70	

TEST TWO

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	4.3	609			19 mg/l				70	
	50	15	25.9	4.3				19	S-1	0.01	4L		
		15 s/s	25.9	4.4				19	S-2	0.00	4L		
	65	30	25.9	4.9	578			19	S-3	0.01	4L	70	
		30 s/s	25.9	4.9				19	S-4	0.01	4L		
	80	45	25.9	5.6				19	S-5	0.02	4L		
		45 s/s	25.9	5.6				19	S-6	0.00	4L		
		50	25.9	5.8				19					
	95	60	25.9	6.4	588			19	S-7	0.02	4L	69	
		60 s/s	25.9	6.5				19	S-8	0.01	4L		
	110	75	25.9	7.6				19	S-9	0.05	4L		
		75 s/s	25.9	7.7				19	S-10	0.02	4L		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST TWO

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	8.4	773	9.8	0.0					70	
	112	2	25.9	8.3		9.8	0.0						
	115	5	25.9	8.3		9.8	0.0						
	125	15	25.9	8.5		9.8	0.0						
	140	30 s/s	25.9	8.3	621	9.8	0.0					70	
	155	45	25.9	8.5		9.8	0.0						
	170	60 s/s	25.9	8.6	605	9.8	0.0						
	185	75	25.9	8.6		9.8	0.0						
	200	90 s/s	25.9	8.7		9.8	0.0					69	
	215	105	25.9	8.7	612	9.8	0.0						
	230	120 s/s	25.9	8.8		9.8	0.0						
	245	135	25.9	8.8		9.8	0.0						
	260	150 s/s	25.9	8.9		9.8	0.0						
Water Coalescence Test 3%	260	0	25.9	8.2	602	.78 gal	0.0					69	
	262	2	25.9	16.5		.78	0.0						¼" drops
	265	5	25.9	18.5		.78	0.0						
	270	10 s/s	25.9	19.4	741	.78	0.0						
	280	20 s/s	25.9	21.1		.78	0.0						
	290	30	25.9	21.7	805	.78	0.0					69	Inlet c.u. = 751

TEST THREE

Test Specification: API 1581 5th Edition	50/50 Blend Fuel with FSII only		**Date** 03/14/11
Vessel: Horizontal	**Filter/Coalescer:** TC-C0162 CM14SB-5	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:				
Tank Volume **Gallon**		Conc.	Amt. Added	k (ps/m)
10,474 Gal.	**FSII**	0.15%	15.71	00
Note:				

Mixing Time (min): 20 min

Element Conditioning: ☐-In-Situ **Time (min)**

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m) effluent	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sampl e Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	4.0	00				M-3	5 gal	2	70	MSEPA= 98
Water 0.01%	5	0	25.9	4.0	00	9.8	0.0						
	10	5	25.6	4.2		9.8	0.0						
	15	10 s/s	25.9	4.6		9.8	0.0						
	25	20 s/s	25.9	5.5		9.8	0.0						
	35	30 s/s	25.9	6.1	00	9.8	0.0					69	

TEST THREE

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	6.2	00			19 mg/l				69	
	50	15	25.9	6.2				19	S-1	0.00	4L		
		15 s/s	25.9	6.2				19	S-2	0.05	4L		
	65	30	25.9	6.3	00			19	S-3	0.03	4L	69	
		30 s/s	25.9	6.3				19	S-4	0.07	4L		
	80	45	25.9	6.7				19	S-5	0.01	4L		
		45 s/s	25.9	6.7				19	S-6	0.05	4L		
		50	25.9	6.8				19					
	95	60	25.9	7.1	00			19	S-7	0.03	4L	69	
		60 s/s	25.9	7.1				19	S-8	0.09	4L		
	110	75	25.9	7.9				19	S-9	0.05	4L		
		75 s/s	25.9	7.9				19	S-10	0.02	4L		

[a] s/s: sample taken immediately after conclusion of stop/start

TEST THREE

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	7.7	00	9.8	0.0					69	
	112	2	25.9	7.9		9.8	0.0						
	115	5	25.9	8.1		9.8	0.0						
	125	15	25.9	8.8		9.8	0.0						
	140	30 s/s	25.9	9.3	00	9.8	0.0					68	
	155	45	25.9	9.3		9.8	0.0						
	170	60 s/s	25.9	9.4	00	9.8	0.0						
	185	75	25.9	9.6		9.8	0.0						
	200	90 s/s	25.9	9.7		9.8	0.0					68	
	215	105	25.9	9.7	00	9.8	0.0						
	230	120 s/s	25.9	9.8		9.8	0.0						
	245	135	25.9	9.9		9.8	0.0						
	260	150 s/s	25.9	10.0		9.8	0.0						
Water Coalescence Test 3%	260	0	25.9	8.8	00	.78 gal	0.0					68	
	262	2	25.9	14.6		.78	0.0						¼” drops
	265	5	25.9	15.7		.78	0.0						
	270	10 s/s	25.9	17.3	00	.78	0.0						
	280	20 s/s	25.9	22.1		.78	0.0						
	290	30	25.9	24.2	00	.78	0.0					67	Inlet c.u. = 00

TEST FOUR

Test Specification: API 1581 5th Edition	Test 4, 50/50 Blend Fuel with CI/LI only		**Date** 03/16/11
Vessel: Horizontal	**Filter/Coalescer:** TC-C0162 CM14SB-5	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:				
Tank Volume	**Gallon**			
11,138	Gal.			
Note:				

	Conc.	Amt. Added	k (ps/m)
CI/LI	15 mg/l	632	02

Mixing Time (min): 20 min

Element Conditioning: ☐-In-Situ

Phase	Cum. Time (min)	Time (min) 0	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m) effluent	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑ºF	Notes/Comments
Start-up	0	0	25.9	3.8	01				M-4	5 gal	3	73	MSEPA= 96
Water 0.01%	5	0	25.9	3.8	00	9.8	0.0						
	10	5	25.6	4.0		9.8	0.0						
	15	10 s/s	25.9	4.1		9.8	0.0						
	25	20 s/s	25.9	4.8		9.8	0.0						
	35	30 s/s	25.9	4.9	00	9.8	0.0					72	

TEST FOUR

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	5.0	01			19 mg/l				72	
	50	15	25.9	5.2				19	S-1	0.01	4L		
		15 s/s	25.9	5.2				19	S-2	0.03	4L		
	65	30	25.9	5.4	01			19	S-3	0.06	4L	72	
		30 s/s	25.9	5.5				19	S-4	0.05	4L		
	80	45	25.9	5.8				19	S-5	0.09	4L		
		45 s/s	25.9	5.9				19	S-6	0.01	4L		
		50	25.9	6.3				19					
	95	60	25.9	7.0	00			19	S-7	0.01	4L	71	
		60 s/s	25.9	7.0				19	S-8	0.00	4L		
	110	75	25.9	7.8				19	S-9	0.01	4L		
		75 s/s	25.9	7.9				19	S-10	0.02	4L		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST FOUR

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑ºF	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	8.8	02	9.8	0.0					71	
	112	2	25.9	9.0		9.8	0.0						
	115	5	25.9	9.0		9.8	0.0						
	125	15	25.9	9.6		9.8	0.0						
	140	30 s/s	25.9	10.0	01	9.8	0.0					72	
	155	45	25.9	10.1		9.8	0.0						
	170	60 s/s	25.9	10.3	01	9.8	0.0						
	185	75	25.9	10.6		9.8	0.0						
	200	90 s/s	25.9	10.8		9.8	0.0					71	
	215	105	25.9	11.1	00	9.8	0.0						
	230	120 s/s	25.9	11.3		9.8	0.0						
	245	135	25.9	11.4		9.8	0.0						
	260	150 s/s	25.9	11.5		9.8	0.0						
Water Coalescence Test 3%	260	0	25.9	10.8	01	.78 gal	0.0					71	
	262	2	25.9	19.5		.78	1.0						1/8 – 1/4” drops
	265	5	25.9	22.6		.78	0.0						
	270	10 s/s	25.9	24.8	01	.78	0.5						Some fines developed
	280	20 s/s	25.9	27.7		.78	0.5						
	290	30	25.9	29.8	01	.78	0.5					71	Inlet c.u. = 01

TEST FIVE

Test Specification: API 1581 5th Edition — 50/50 Blend Fuel with SDA and FSII only — **Date** 03/17/11

Vessel: Horizontal | **Filter/Coalescer:** TC-C0162 CM14SB-5 | **Separator:** SM-07FF-5 | **Type**:

Additive Addition	**Model**	**Number**	**Model**	**Number**

Category:

Tank Volume	Gallon		Conc.	Amt. Added	k (ps/m)
11,118	Gal.	**Stadis**	2.0 mg/i	84.17 g	755
		FSII	0.15%	16.68 gal	946

Note:

Mixing Time (min): 20 min

Element Conditioning: ☐-In-Situ

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m) effluent	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	4.1	58				M-5	5 gal	4	73	MSEPA= 48
Water 0.01%	5	0	25.9	4.3	415	9.8	0.0						
	10	5	25.6	4.4		9.8	0.0						
	15	10 s/s	25.9	4.7		9.8	0.0						
	25	20 s/s	25.9	4.9		9.8	0.0						
	35	30 s/s	25.9	5.1	690	9.8	0.0					73	

TEST FIVE

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	5.1	690			19 mg/l				72	
	50	15	25.9	5.8				19	S-1	0.03	4L		
		15 s/s	25.9	5.9				19	S-2	0.03	4L		
	65	30	25.9	7.2	705			19	S-3	0.05	4L	71	
		30 s/s	25.9	7.2				19	S-4	0.06	4L		
	80	45	25.9	8.8				19	S-5	0.04	4L		
		45 s/s	25.9	8.8				19	S-6	0.04	4L		
		50	25.9	9.5				19					
	95	60	25.9	10.4	723			19	S-7	0.04	4L	71	
		60 s/s	25.9	10.4				19	S-8	0.04	4L		
	110	75	25.9	12.3				19	S-9	0.03	4L		
		75 s/s	25.9	12.3				19	S-10	0.02	4L		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST FIVE

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	13.2	760	9.8	0.0					71	
	112	2	25.9	13.3		9.8	0.0						
	115	5	25.9	13.4		9.8	0.0						
	125	15	25.9	13.4		9.8	0.0						
	140	30 s/s	25.9	12.7	775	9.8	0.5					71	
	155	45	25.9	13.3		9.8	0.0						
	170	60 s/s	25.9	13.5	796	9.8	0.0						
	185	75	25.9	13.5		9.8	0.0						
	200	90 s/s	25.9	13.2		9.8	0.0					71	
	215	105	25.9	13.7	814	9.8	0.0						
	230	120 s/s	25.9	14.0		9.8	0.0						
	245	135	25.9	13.9		9.8	0.5						
	260	150 s/s	25.9	14.1		9.8	0.0						
Water Coalescence Test 3%	260	0	25.9	13.1	792	.78 gal	0.0					72	
	262	2	25.9	20.4		.78	0.0						1/4” drops
	265	5	25.9	22.4		.78	0.0						
	270	10 s/s	25.9	23.4	908	.78	0.0						
	280	20 s/s	25.9	24.6		.78	0.0						
	290	30	25.9	24.3	886	.78	0.0					72	Inlet c.u. = 963

Test Six

Test Specification: API 1581 5th Edition	50/50 Blend Fuel with SDA and CI/LI only		**Date** 03/21/11
Vessel: Horizontal	**Filter/Coalescer:** TC-C0162 CM14SB-5	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:				
Tank Volume / **Gallon**		Conc.	Amt. Added	k (ps/m)
11,217 Gal.	**Stadis**	2.0 mg/i	84.9	724
Note:	**CI/LI**	15 mg/l	637	753
Mixing Time (min):			20 min	
Element Conditioning: ☐-In-Situ	**Time (min)**			

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m) effluent	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sampl e Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	4.0	286				M-6	5 gal	2	73	MSEPA= 56
Water 0.01%	5	0	25.9	4.1	570	9.8	0.0						
	10	5	25.6	4.2		9.8	0.0						
	15	10 s/s	25.9	4.5		9.8	0.0						
	25	20 s/s	25.9	4.9		9.8	0.0						
	35	30 s/s	25.9	5.1	610	9.8	0.0					72	

TEST SIX

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	5.1	615			19 mg/l				72	
	50	15	25.9	5.3				19	S-1	0.04	4L		
		15 s/s	25.9	5.3				19	S-2	0.01	4L		
	65	30	25.9	5.7	611			19	S-3	0.02	4L	71	
		30 s/s	25.9	5.7				19	S-4	0.01	4L		
	80	45	25.9	6.4				19	S-5	0.03	4L		
		45 s/s	25.9	6.4				19	S-6	0.02	4L		
		50	25.9	6.7				19					
	95	60	25.9	7.3	620			19	S-7	0.00	4L	71	
		60 s/s	25.9	7.3				19	S-8	0.02	4L		
	110	75	25.9	8.7				19	S-9	0.01	4L		
		75 s/s	25.9	8.7				19	S-10	0.02	4L		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST SIX

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	9.3	570	9.8	0.0					71	
	112	2	25.9	9.6		9.8	0.0						
	115	5	25.9	10.1		9.8	0.0						
	125	15	25.9	10.6		9.8	0.0						
	140	30 s/s	25.9	11.1	613	9.8	0.0					71	
	155	45	25.9	11.4		9.8	0.0						
	170	60 s/s	25.9	11.9	628	9.8	0.0						
	185	75	25.9	12.1		9.8	0.0						
	200	90 s/s	25.9	12.7		9.8	0.0					71	
	215	105	25.9	12.9	631	9.8	0.0						
	230	120 s/s	25.9	13.2		9.8	0.0						
	245	135	25.9	13.3		9.8	0.0						
	260	150 s/s	25.9	13.6		9.8	0.0						
Water Coalescence Test 3%	260	0	25.9	11.8	634	.78 gal	0.0					71	
	262	2	25.9	22.8		.78	0.5						1/32-1/4"'drops
	265	5	25.9	25.8		.78	1.5						
	270	10 s/s	25.9	27.4	734	.78	2.0						
	280	20 s/s	25.9	31.3		.78	4.0						
	290	30	25.9	33.7	745	.78	3.5					71	Inlet c.u. = 761

TEST SEVEN

Test Specification: API 1581 5th Edition	50/50 Blend Fuel with FSII and CI/LI only		**Date** 03/22/11
Vessel: Horizontal	**Filter/Coalescer:** TC-C0162 CM14SB-5	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:					
Tank Volume	**Gallon**		Conc.	Amt. Added	k (ps/m)
11,138	Gal.	**FSII**	0.15%	16.7	002
Note:		**CI/LI**	15 mg/l	632 g	001

Mixing Time (min): 20 min

Element Conditioning: ☐-In-Situ

Phase	Cum. Time (min)	Time (min) 0	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m) effluent	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	4.1	001				M-7	5 gal	3	71	MSEPA= 84
Water 0.01%	5	0	25.9	4.1	001	9.8	0.0						
	10	5	25.6	4.5		9.8	0.0						
	15	10 s/s	25.9	4.8		9.8	0.0						
	25	20 s/s	25.9	5.1		9.8	0.0						
	35	30 s/s	25.9	5.4	002	9.8	0.0					72	

TEST SEVEN

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	5.4	001			19 mg/l				72	
	50	15	25.9	5.4				19	S-1	0.02	4L		
		15 s/s	25.9	5.4				19	S-2	----	4L		Torn pad
	65	30	25.9	5.8	001			19	S-3	0.01	4L	72	
		30 s/s	25.9	5.8				19	S-4	0.05	4L		
	80	45	25.9	6.6				19	S-5	0.02	4L		
		45 s/s	25.9	6.7				19	S-6	0.07	4L		
		50	25.9	7.0				19					
	95	60	25.9	7.6	002			19	S-7	0.03	4L	72	
		60 s/s	25.9	7.6				19	S-8	0.01	4L		
	110	75	25.9	9.1				19	S-9	0.03	4L		
		75 s/s	25.9	9.2				19	S-10	0.01	4L		

[a]s/s: sample taken immediately after conclusion of stop/start

TEST SEVEN

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	9.9	001	9.8	0.0					72	
	112	2	25.9	10.2		9.8	0.0						
	115	5	25.9	10.3		9.8	0.0						
	125	15	25.9	10.8		9.8	0.0						
	140	30 s/s	25.9	11.5	000	9.8	0.0					73	
	155	45	25.9	11.4		9.8	0.0						
	170	60 s/s	25.9	11.7	002	9.8	0.0						
	185	75	25.9	11.7		9.8	0.0						
	200	90 s/s	25.9	11.9		9.8	0.0					73	
	215	105	25.9	11.9	002	9.8	0.0						
	230	120 s/s	25.9	12.2		9.8	0.0						
	245	135	25.9	12.2		9.8	0.0						
	260	150 s/s	25.9	12.4		9.8	0.5						
Water Coalescence Test 3%	260	0	25.9	11.0	001	.78 gal	0.0					74	
	262	2	25.9	19.7		.78	0.5						1/32-1/4"'drops
	265	5	25.9	21.0		.78	1.0						
	270	10 s/s	25.9	25.4	001	.78	1.5						Fines developed
	280	20 s/s	25.9	28.7		.78	2.0						
	290	30	25.9	31.0	001	.78	2.0					74	Inlet c.u. = 001

TEST EIGHT

Test Specification: API 1581 5th Edition — Test 8, 50/50 Blend Fuel with DSA, FSII and CI/LI — **Date** 03/24/11

Vessel: Horizontal | **Filter/Coalescer:** TC-C0162 CM14SB-5 | **Separator:** SM-07FF-5 | **Type**:

Additive Addition | Model | Number | Model | Number

Category:

Tank Volume	Gallon		Conc.	Amt. Added	k (ps/m)
11217	Gal.	SDA	2.0 mg/l	84.9	741
Note:		FSII	0.15%	16.8	923
		CI/LI	15 mg/l	637	930

Mixing Time (min): 20 min

Element Conditioning: ☐-In-Situ — Time (min)

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (Ps/m) effluent	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	3.9	042				M-8	5 gal	1	72	MSEPA= 44
Water 0.01%	5	0	25.9	3.9	323	9.8	0.0						
	10	5	25.6	4.0		9.8	0.0						
	15	10 s/s	25.9	4.3		9.8	0.0						
	25	20 s/s	25.9	4.6		9.8	0.0						
	35	30 s/s	25.9	4.8	356	9.8	0.0					72	

TEST EIGHT

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	4.8	387			19 mg/l				72	
	50	15	25.9	4.8				19	S-1	0.04	4L		
		15 s/s	25.9	4.9				19	S-2	0.05	4L		
	65	30	25.9	5.2	406			19	S-3	0.04	4L	72	
		30 s/s	25.9	5.2				19	S-4	0.03	4L		
	80	45	25.9	6.0				19	S-5	0.03	4L		
		45 s/s	25.9	6.1				19	S-6	0.05	4L		
		50	25.9	6.4				19					
	95	60	25.9	7.1	395			19	S-7	0.04	4L	72	
		60 s/s	25.9	7.1				19	S-8	0.04	4L		
	110	75	25.9	8.7				19	S-9	0.03	4L		
		75 s/s	25.9	8.7				19	S-10	0.01	4L		

[a] s/s: sample taken immediately after conclusion of stop/start

TEST EIGHT

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑ºF	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	10.1	427	9.8	0.0					72	
	112	2	25.9	11.2		9.8	0.0						
	115	5	25.9	11.9		9.8	0.0						
	125	15	25.9	12.6		9.8	0.0						
	140	30 s/s	25.9	13.6	645	9.8	0.0					72	
	155	45	25.9	15.0		9.8	0.0						
	170	60 s/s	25.9	16.6	673	9.8	0.0						
	185	75	25.9	17.5		9.8	0.0						
	200	90 s/s	25.9	18.7		9.8	1.0					72	
	215	105	25.9	18.8	682	9.8	1.0						
	230	120 s/s	25.9	20.4		9.8	1.0						
	245	135	25.9	20.1		9.8	1.0						
	260	150 s/s	25.9	21.1		9.8	1.0						
Water Coalescence Test 3%	260	0	25.9	16.0	741	.78 gal	0.0					72	
	262	2	25.9	26.7		.78	0.0						3/16 - 1/32 "'drops
	265	5	25.9	28.9		.78	0.0						
	270	10 s/s	25.9	31.1	812	.78	0.0						
	280	20 s/s	25.9	33.2		.78	0.0						
	290	30	25.9	34.1	774	.78	0.0					72	Inlet c.u. = 940

TEST NINE

Test Specification: API 1581 5th Edition	50/50 Blend Fuel with SDA, FSII, CI/LI	**Date** 03/29/11

Vessel: Horizontal	**Filter/Coalescer:**	TC-C0162 CM14SB-5	**Separator:**	SM-07FF-5		**Type**:
Additive Addition	**Model**	**Number**	**Model**	**Number**		

Category:			
Tank Volume Gallon	Conc.	Amt. Added	K (ps/m)
11098 Gal. SDA	2.0mg/l	84.02	779
Note: FSII	0.15%	16.6	980
CI/LI	15mg/l	630	981

Mixing Time (min): 20 min

Element Conditioning: ☐-In-Situ

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m) effluent	Time (min) Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	25.9	3.9	039				M-9	5 gal	3	75	MSEPA= 43
Water 0.01%	5	0	25.9	3.9	395	9.8	0.0						
	10	5	25.6	4.2		9.8	0.0						
	15	10 s/s	25.9	4.4		9.8	0.0						
	25	20 s/s	25.9	4.7		9.8	0.0						
	35	30 s/s	25.9	4.9	335	9.8	0.5					73	

TEST NINE

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	25.9	4.9	340			19 mg/l				73	
	50	15	25.9	4.7				19	S-1	0.06	4L		
		15 s/s	25.9	4.7				19	S-2	0.08	4L		
	65	30	25.9	5.0	303			19	S-3	0.08	4L	73	
		30 s/s	25.9	5.0				19	S-4	0.07	4L		
	80	45	25.9	5.8				19	S-5	0.07	4L		
		45 s/s	25.9	5.7				19	S-6	0.07	4L		
		50	25.9	6.8				19					
	95	60	25.9	6.8	405			19	S-7	0.05	4L	72	
		60 s/s	25.9	6.8				19	S-8	0.01	4L		
	110	75	25.9	8.7				19	S-9	0.04	4L		
		75 s/s	25.9	8.3				19	S-10	0.04	4L		

[a] s/s: sample taken immediately after conclusion of stop/start

TEST NINE

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	25.9	9.3	466	9.8	0.0					72	
	112	2	25.9	12.2		9.8	0.0						
	115	5	25.9	13.7		9.8	0.0						
	125	15	25.9	17.0		9.8	0.0						
	140	30 s/s	25.9	17.4	630	9.8	0.0					72	
	155	45	25.9	20.3		9.8	0.0						
	170	60 s/s	25.9	18.7	667	9.8	0.0						
	185	75	25.9	20.4		9.8	0.0						
	200	90 s/s	25.9	21.7		9.8	0.5					72	
	215	105	25.9	21.9	721	9.8	0.0						
	230	120 s/s	25.9	22.5		9.8	0.0						
	245	135	25.9	22.3		9.8	0.5						
	260	150 s/s	25.9	22.9		9.8	0.0						
Water Coalescence Test 0.5%	260	0	25.9	19.5	719	.13 gal	0.0					72	
	262	2	25.9	26.6		.13	0.0						Mostly 1/8” drops
	265	5	25.9	31.0		.13	0.0						
	270	10 s/s	25.9	33.6	757	.13	0.0						
	280	20 s/s	25.9	37.9		.13	0.5						
	290	30	25.9	40.2	786	.13	0.5					73	Inlet c.u. = 890

TEST 10

Test Specification: API 1581 5th Edition	50/50 Blend Fuel with DSA, FSII and CI/LI		**Date** 03/31/11
Vessel: Horizontal	**Filter/Coalescer:** TC-C0162 CM14SB-5	**Separator:** SM-07FF-5	**Type**:
Additive Addition	**Model** / **Number**	**Model** / **Number**	

Category:	Conc.	Amt. Added	k (ps/m)
Tank Volume Gallon			
11257 Gal.			
DSA	2.0 mg/l	85.2	823
FSII	0.15%	16.9	910
CI/LI	15 mg/l	639	927

Note:

Mixing Time (min): 20 min

Element Conditioning: ☐-In-Situ **Time (min)**

Phase	Cum. Time (min)	0	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m) effluent	Water Flow Rate ☑ml/min	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Sample Size	Fibers per gallon	Temp. ☑°F	Notes/Comments
Start-up	0	0	34.0	5.3	103				M-10	5 gal	1	72	MSEPA= 50
Water 0.01%	5	0	34.0	5.3	410	12.9	0.0						
	10	5	34.0	5.8		12.9	0.0						
	15	10 s/s	34.0	6.1		12.9	0.0						
	25	20 s/s	34.0	6.5		12.9	0.5						
	35	30 s/s	34.0	6.8	453	12.9	0.0					70	

TEST 10

Table 6—Data Sheet for Single-Element Tests (continued) (Note: For Type S Filters Only)

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	K (pS/m)	Water Flow Rate ☐ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☑mg/l	Filter Sample ID	Solids Conc. (g/l)	Sample Size	Temp. ☑°F	Notes/Comments
Solids Holding Test	35	0	34.0	6.7	453			19 mg/l				70	
	50	15	34.0	6.9				19	S-1	0.09	4L		
		15 s/s	34.0	7.0				19	S-2	0.05	4L		
	65	30	34.0	7.8	392			19	S-3	0.02	4L	70	
		30 s/s	34.0	7.9				19	S-4	0.01	4L		
	80	45	34.0	10.2				19	S-5	0.02	4L		
		45 s/s	34.0	10.4				19	S-6	0.02	4L		
		50	34.0	12.1				19					
	95	60	34.0	15.0	450			19	S-7	0.02	4L	70	
		60 s/s	34.0	15.1				19	S-8	0.02	4L		
	110	75	34.0	20.9				19	S-9	0.03	4L		
		75 s/s	34.0	21.0				19	S-10	0.03	4L		

[a] s/s: sample taken immediately after conclusion of stop/start

TEST 10

Phase	Cum. Time (min)	Time (min)	Fuel Flow Rate (gpm)	ΔP (psi)	k (pS/m)	Water Flow Rate ☑ml/min ☐gpm	Water Conc. (ppm)	Solids Rate ☐mg/l ☐mg/gal	Filter Sample ID	Solids Conc. (mg/l)	Sample Size	Temp. ☑°F	Notes/Comments
Water Coalescence Test – 0.01%	110	0	34.0	23.8	490	12.9	0.0					70	
	112	2	34.0	30.2		12.9	0.0						
	115	5	34.0	32.2		12.9	0.0						
	125	15	34.0	34.6		12.9	0.5						
	140	30 s/s	34.0	37.2	665	12.9	0.5					69	
	155	45	34.0	38.0		12.9	0.5						
	170	60 s/s	34.0	39.9	691	12.9	1.0						
	185	75	34.0	40.9		12.9	0.5						
	200	90 s/s	34.0	42.5		12.9	0.5					69	
	215	105	34.0	42.3	715	12.9	0.5						
	230	120 s/s	34.0	43.2		12.9	0.5						
	245	135	34.0	43.7		12.9	0.5						
	260	150 s/s	34.0	44.6		12.9	1.0						
Water Coalescence Test 3%	260	0	34.0	40.7	710	1.02 gal	0.0					69	
	262	2	34.0	57.6		1.02	1.0						1/8"'drops, many fines
	265	5	34.0	61.7		1.02	1.0						
	270	10 s/s	34.0	65.4	720	1.02	1.5						Test not completed
													Insufficient fuel volume

Appendix I

Phase II Fuel Sample Test Data

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30398001 | Date Received:03/14/11 1234 hrs* | Date Sampled: 03/09/2011**
Cust Sample No:POSF7405 | Date Reported:03/17/11 1713 hrs* | Protocol:FU-AVI-0126
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Neat Receipt
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ

Source: Truck #1 | Qty Submitted: 1 gal | Qty Rep: 6,500 gal

Method	Test	Min	Max	Result	Fail
ASTM D 5453 - 09	Sulfur (% mass)		0.0015	0.00	
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		142	
	10% Recovered (°C)		205	164	
	20% Recovered (°C)	Report Only		176	
	50% Recovered (°C)	Report Only		217	
	90% Recovered (°C)	Report Only		260	
	End Point (°C)		300	267	
	T90 - T10 (°C)	22		96	
	Residue (% vol)		1.5	1.5	
	Loss (% vol)		1.5	0.3	
ASTM D 93 - 10a	Flash Point (°C)	38		46	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.751	0.770	0.759	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-55	
ASTM D 445 - 10	Viscosity @ -20°C (mm²/s)		8.0	5.1	
ASTM D 445 - 10	Viscosity @ -40°C (mm²/s)	Report Only		11.9	
ASTM D 445 - 10	Viscosity @ 40°C (mm²/s)	Report Only		1.4	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		44.0	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		15.3	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		>45.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 325°C				
	Tube Deposit Rating, Visual	<3		0	
	Change in Pressure (mmHg)		25	1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 2624 - 09	Conductivity				
	Conductivity (pS/m)	Report Only		154	
	Test Temperature (°F)			70	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.51	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)		75	13	
ASTM D 7224 - 08	WSIM	70		78	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.08	X
GC	Gas Chromatographic Analysis			See Below	

Dispositions:
For information purposes only.

* Date reflects Eastern Standard Time(EST) | Report Generated: 03/17/11 17:13*
** Date as provided by customer

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30398001	Date Received:03/14/11 1234 hrs*	Date Sampled: 03/09/2011**
Cust Sample No:POSF7405	Date Reported:03/17/11 1713 hrs*	Protocol:FU-AVI-0126
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

* Neat tallow HRJ sample from receipt truck #1. This is from the filter evaluation testing being done at Facet (Greensboro NC). Volume represented: approx 6,500 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.
* GC is that of a typical HRJ-type fuel.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	03/17/2011*

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30400001 Date Received:03/14/11 1242 hrs* Date Sampled: 03/09/2011**
Cust Sample No:POSF7407 Date Reported:03/16/11 1559 hrs* Protocol:FU-AVI-0133
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:JP-8

Source: none listed Qty Submitted: 1 gal Qty Rep: 6,500 gal

Method	Test	Min	Max	Result
ASTM D 5453 - 09	Sulfur (% mass)		0.30	0.03
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004
ASTM D 1319 - 10	Aromatics (% vol)		25.0	17.4
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.001
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		146
	10% Recovered (°C)		205	175
	20% Recovered (°C)	Report Only		184
	50% Recovered (°C)	Report Only		203
	90% Recovered (°C)	Report Only		239
	End Point (°C)		300	262
	Residue (% vol)		1.5	1.4
	Loss (% vol)		1.5	0.2
ASTM D 93 - 10a	Flash Point (°C)	38		50
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.802
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-51
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.5
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		9.2
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.2
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		13.8
ASTM D 1322 - 08	Smoke Point (mm)	25.0		26.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)		1 (Max)	1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual		<3 (Max)	1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.10
ASTM D 7224 - 08	WSIM	70		86
ASTM D 2624 - 09	Conductivity (pS/m)	Report Only		93
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.50
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		22

Dispositions:
For information purposes only.
JP-8 sample from the filter coalescer certification verification testing being done at Facet (Greensboro NC). Volume represented: approx 6,500 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

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HQ AFPET/PTPLA
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Lab Report No:2011LA30400001	Date Received:03/14/11 1242 hrs*	Date Sampled: 03/09/2011**
Cust Sample No:POSF7407	Date Reported:03/16/11 1559 hrs*	Protocol:FU-AVI-0133
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	03/16/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30399001 Date Received:03/14/11 1239 hrs* Date Sampled: 03/09/2011**
Cust Sample No:POSF7406 Date Reported:03/17/11 1715 hrs* Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: Facet Tanks Qty Submitted: 1 gal

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.002	
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.1	
ASTM D 5453 - 09	Sulfur (% mass)		0.30	0.02	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.001	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		144	
	10% Recovered (°C)		205	170	
	20% Recovered (°C)	Report Only		180	
	50% Recovered (°C)	Report Only		209	
	90% Recovered (°C)	Report Only		252	
	End Point (°C)		300	268	
	T50 - T10 (°C)	15		39	
	T90 - T10 (°C)	40		82	
	Residue (% vol)		1.5	1.5	
	Loss (% vol)		1.5	0.2	
ASTM D 93 - 10a	Flash Point (°C)	38		48	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.780	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53	
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.8	
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		10.3	
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.4	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.6	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		35.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 7224 - 08	WSIM	70		96	
ASTM D 2624 - 09	Conductivity				
	Conductivity (pS/m)	Report Only		0	
	Test Temperature (°F)			70	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.69	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		9	

Dispositions:
For information purposes only.

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30399001	Date Received:03/14/11 1239 hrs*	Date Sampled: 03/09/2011**
Cust Sample No:POSF7406	Date Reported:03/17/11 1715 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
Clay-filtered 50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet (Greensboro NC). This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	Date
Miguel Acevedo, Chief \\SIGNED\\	03/17/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31213001 Date Received:04/28/11 0925 hrs* Date Sampled: 04/11/2011**
Cust Sample No:POSF 7430 Date Reported:05/04/11 1945 hrs* Protocol:FU-AVI-0133
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:JP-8

Source: FACET Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST #1, FUEL B4 START

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.002	
ASTM D 1319 - 10	Aromatics (% vol)		25.0	17.1	
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		160	
	10% Recovered (°C)		205	178	
	20% Recovered (°C)	Report Only		184	
	50% Recovered (°C)	Report Only		201	
	90% Recovered (°C)	Report Only		235	
	End Point (°C)		300	257	
	Residue (% vol)		1.5	1.2	
	Loss (% vol)		1.5	0.5	
ASTM D 93 - 10a	Flash Point (°C)	38		50	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.797	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-52	
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.4	
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		8.4	
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.3	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		13.9	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		25.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 7224 - 08	WSIM	Report Only		99	
ASTM D 2624 - 09	Conductivity (pS/m)	Report Only		0	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.65	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		26	

Dispositions:
For information purposes only.

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31213001	Date Received:04/28/11 0925 hrs*	Date Sampled: 04/11/2011**
Cust Sample No:POSF 7430	Date Reported:05/04/11 1945 hrs*	Protocol:FU-AVI-0133
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
JP-8 sample from the filter evaluation testing being done at Facet. Test #1 sample (unadditized fuel sample; no SDA, FSII, or CI/LI fuel additives). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	05/04/2011*

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30671001 | Date Received:03/30/11 0818 hrs* | Date Sampled: 03/10/2011**
Cust Sample No:POSF 7415 | Date Reported:03/30/11 1631 hrs* | Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: Facet | Qty Submitted: 1 gal | Qty Rep: 13,000 gal
Batch/Lot/Origin TEST 1

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.001	
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.4	
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.01	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		151	
	10% Recovered (°C)		205	171	
	20% Recovered (°C)	Report Only		181	
	50% Recovered (°C)	Report Only		210	
	90% Recovered (°C)	Report Only		253	
	End Point (°C)		300	268	
	T50 - T10 (°C)	15		39	
	T90 - T10 (°C)	40		82	
	Residue (% vol)		1.5	1.4	
	Loss (% vol)		1.5	0.5	
ASTM D 93 - 10a	Flash Point (°C)	38		48	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.780	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53	
ASTM D 445 - 10	Viscosity @ -20°C (mm²/s)		8.0	5.3	
ASTM D 445 - 10	Viscosity @ -40°C (mm²/s)	Report Only		10.5	
ASTM D 445 - 10	Viscosity @ 40°C (mm²/s)	Report Only		1.3	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.5	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		27.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 7224 - 08	WSIM	Report Only		98	
ASTM D 2624 - 09	Conductivity				
	Conductivity (pS/m)	Report Only		0	
	Test Temperature (°F)			73	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.68	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		9	

Dispositions:
For information purposes only.

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** Date as provided by customer

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30671001	Date Received:03/30/11 0818 hrs*	Date Sampled: 03/10/2011**
Cust Sample No:POSF 7415	Date Reported:03/30/11 1631 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet (Greensboro NC). Test #1 sample (neat blend sample; no SDA, FSII, or CI/LI fuel additives). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	Date
Miguel Acevedo, Chief \\SIGNED\\	03/30/2011*

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31215001 Date Received:04/28/11 0933 hrs* Date Sampled: 04/12/2011**
Cust Sample No:POSF 7431 Date Reported:05/04/11 2004 hrs* Protocol:FU-AVI-0133
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:JP-8

Source: FACET Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST #2, FUEL B4 START

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.002	
ASTM D 1319 - 10	Aromatics (% vol)		25.0	17.1	
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.03	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		160	
	10% Recovered (°C)		205	177	
	20% Recovered (°C)	Report Only		184	
	50% Recovered (°C)	Report Only		201	
	90% Recovered (°C)	Report Only		235	
	End Point (°C)		300	256	
	Residue (% vol)		1.5	1.3	
	Loss (% vol)		1.5	0.7	
ASTM D 93 - 10a	Flash Point (°C)	38		50	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.797	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-52	
ASTM D 445 - 10	Viscosity @ -20°C (mm²/s)		8.0	4.3	
ASTM D 445 - 10	Viscosity @ -40°C (mm²/s)	Report Only		8.3	
ASTM D 445 - 10	Viscosity @ 40°C (mm²/s)	Report Only		1.3	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.3	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		13.9	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		25.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 7224 - 08	WSIM	Report Only		85	
ASTM D 2624 - 09	Conductivity (pS/m)	Report Only		883	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.66	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		37	

Dispositions:
Coordinated with Emilio Alfaro (PTPT), phone: DSN 785-8050, COM 937-255-8050.
For information purposes only.

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** Date as provided by customer

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31215001	Date Received:04/28/11 0933 hrs*	Date Sampled: 04/12/2011**
Cust Sample No:POSF 7431	Date Reported:05/04/11 2004 hrs*	Protocol:FU-AVI-0133
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

JP-8 sample from the filter evaluation testing being done at Facet. Test #2 sample (SDA only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	05/04/2011*

This report was electronically delivered to:
afpet.afth@wpafb.af.mil, afpet.aftt@wpafb.af.mil, beatriz.rodriguez@wpafb.af.mil, benet.curtis@wpafb.af.mil, david.benson2@wpafb.af.mil, emilio.alfaro@wpafb.af.mil, gordon.walker@wpafb.af.mil, james.edwards@wpafb.af.mil, jeffrey.braun@wpafb.af.mil, jennifer.engelman@wpafb.af.mil, john.datko@wpafb.af.mil, miguel.acevedo@wpafb.af.mil, rhonda.cook@wpafb.af.mil, teresa.boyd@wpafb.af.mil, thomas.harmon@wpafb.af.mil, timothy.mudry@wpafb.af.mil, virgil.regoli@wpafb.af.mil

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30675001 Date Received:03/30/11 0821 hrs* Date Sampled: 03/11/2011**
Cust Sample No:POSF 7416 Date Reported:03/30/11 1635 hrs* Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: Facet Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST 2

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.001	
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.4	
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.01	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		152	
	10% Recovered (°C)		205	172	
	20% Recovered (°C)	Report Only		182	
	50% Recovered (°C)	Report Only		210	
	90% Recovered (°C)	Report Only		253	
	End Point (°C)		300	268	
	T50 - T10 (°C)	15		38	
	T90 - T10 (°C)	40		81	
	Residue (% vol)		1.5	1.4	
	Loss (% vol)		1.5	0.6	
ASTM D 93 - 10a	Flash Point (°C)	38		48	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-54	
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.8	
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		10.4	
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.4	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.4	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		25.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 7224 - 08	WSIM	Report Only		87	
ASTM D 2624 - 09	Conductivity				
	Conductivity (pS/m)	Report Only		700	
	Test Temperature (°F)			73	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.68	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		11	

Dispositions:
For information purposes only.

* Date reflects Eastern Standard Time(EST) | Report Generated: 03/30/11 16:35*
** Date as provided by customer

AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30675001	Date Received:03/30/11 0821 hrs*	Date Sampled: 03/11/2011**
Cust Sample No:POSF 7416	Date Reported:03/30/11 1635 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet (Greensboro NC). Test #2 sample (SDA only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	03/30/2011*

This report was electronically delivered to:
afpet.afth@wpafb.af.mil, afpet.aftt@wpafb.af.mil, beatriz.rodriguez@wpafb.af.mil, benet.curtis@wpafb.af.mil, david.benson2@wpafb.af.mil, emilio.alfaro@wpafb.af.mil, gordon.walker@wpafb.af.mil, james.edwards@wpafb.af.mil, jeffrey.braun@wpafb.af.mil, jennifer.engelman@wpafb.af.mil, john.datko@wpafb.af.mil, miguel.acevedo@wpafb.af.mil, rhonda.cook@wpafb.af.mil, teresa.boyd@wpafb.af.mil, thomas.harmon@wpafb.af.mil, timothy.mudry@wpafb.af.mil, virgil.regoli@wpafb.af.mil

AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31217001 Date Received:04/28/11 0935 hrs* Date Sampled: 04/14/2011**
Cust Sample No:POSF 7432 Date Reported:05/06/11 1415 hrs* Protocol:FU-AVI-0133
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:JP-8

Source: FACET Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST #3 FUEL B4
START

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.002
ASTM D 1319 - 10	Aromatics (% vol)		25.0	17.4
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		159
	10% Recovered (°C)		205	177
	20% Recovered (°C)	Report Only		184
	50% Recovered (°C)	Report Only		201
	90% Recovered (°C)	Report Only		234
	End Point (°C)		300	259
	Residue (% vol)		1.5	1.0
	Loss (% vol)		1.5	0.5
ASTM D 93 - 10a	Flash Point (°C)	38		51
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.797
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-52
ASTM D 445 - 10	Viscosity @ -20°C (mm²/s)		8.0	4.2
ASTM D 445 - 10	Viscosity @ -40°C (mm²/s)	Report Only		8.5
ASTM D 445 - 10	Viscosity @ 40°C (mm²/s)	Report Only		1.3
ASTM D 4809 09a	Net Heat of Combustion (MJ/kg)	42 8		43 2
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		13.9
ASTM D 1322 - 08	Smoke Point (mm)	25.0		25.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.13
ASTM D 7224 - 08	WSIM	Report Only		93
ASTM D 2624 - 09	Conductivity (pS/m)	Report Only		0
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.72
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		31

Dispositions:
For information purposes only.
JP-8 sample from the filter evaluation testing being done at Facet. Test #3 sample (FSII only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

* Date reflects Eastern Standard Time(EST) | Report Generated: 05/6/11 14:15*
** Date as provided by customer

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31217001	Date Received:04/28/11 0935 hrs*	Date Sampled: 04/14/2011**
Cust Sample No:POSF 7432	Date Reported:05/06/11 1415 hrs*	Protocol:FU-AVI-0133
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	05/06/2011*

This report was electronically delivered to:
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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30676001 Date Received:03/30/11 0822 hrs* Date Sampled: 03/14/2011**
Cust Sample No:POSF 7417 Date Reported:04/01/11 0849 hrs* Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: Facet Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST 3

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.001
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.5
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.01
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		152
	10% Recovered (°C)		205	171
	20% Recovered (°C)	Report Only		182
	50% Recovered (°C)	Report Only		209
	90% Recovered (°C)	Report Only		253
	End Point (°C)		300	268
	T50 - T10 (°C)	15		39
	T90 - T10 (°C)	40		83
	Residue (% vol)		1.5	1.4
	Loss (% vol)		1.5	0.4
ASTM D 93 - 10a	Flash Point (°C)	38		48
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.8
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		10.7
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.5
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6
ASTM D 1322 - 08	Smoke Point (mm)	25.0		28.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.12
ASTM D 7224 - 08	WSIM	Report Only		98
ASTM D 2624 - 09	Conductivity			
	Conductivity (pS/m)	Report Only		0
	Test Temperature (°F)			70
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.72
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		17

Dispositions:
For information purposes only.

* Date reflects Eastern Standard Time(EST) | Report Generated: 04/1/11 08:50*
** Date as provided by customer

AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30676001	Date Received:03/30/11 0822 hrs*	Date Sampled: 03/14/2011**
Cust Sample No:POSF 7417	Date Reported:04/01/11 0849 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet. Test #3 sample (FSII only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	04/01/2011*

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afpet.afth@wpafb.af.mil, afpet.aftt@wpafb.af.mil, beatriz.rodriguez@wpafb.af.mil, benet.curtis@wpafb.af.mil, david.benson2@wpafb.af.mil, emilio.alfaro@wpafb.af.mil, gordon.walker@wpafb.af.mil, james.edwards@wpafb.af.mil, jeffrey.braun@wpafb.af.mil, jennifer.engelman@wpafb.af.mil, john.datko@wpafb.af.mil, miguel.acevedo@wpafb.af.mil, rhonda.cook@wpafb.af.mil, teresa.boyd@wpafb.af.mil, thomas.harmon@wpafb.af.mil, timothy.mudry@wpafb.af.mil, virgil.regoli@wpafb.af.mil

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** Date as provided by customer

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31219001 Date Received:04/28/11 0939 hrs* Date Sampled: 04/18/2011**
Cust Sample No:POSF 7433 Date Reported:05/04/11 2006 hrs* Protocol:FU-AVI-0133
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:JP-8

Source: FACET Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST #4 FUEL B4 START

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004	
ASTM D 1319 - 10	Aromatics (% vol)		25.0	17.1	
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		160	
	10% Recovered (°C)		205	177	
	20% Recovered (°C)	Report Only		184	
	50% Recovered (°C)	Report Only		202	
	90% Recovered (°C)	Report Only		235	
	End Point (°C)		300	258	
	Residue (% vol)		1.5	1.1	
	Loss (% vol)		1.5	0.9	
ASTM D 93 - 10a	Flash Point (°C)	38		50	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.797	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-52	
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.2	
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		8.5	
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.3	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		13.9	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		25.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 7224 - 08	WSIM	Report Only		88	
ASTM D 2624 - 09	Conductivity (pS/m)	Report Only		0	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.58	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		22	

Dispositions:

Coordinated with Emilio Alfaro (PTPT), phone: DSN 785-8050, COM 937-255-8050.
For information purposes only.

* Date reflects Eastern Standard Time(EST) | Report Generated: 05/4/11 20:06*
** Date as provided by customer

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31219001 Date Received:04/28/11 0939 hrs* Date Sampled: 04/18/2011**
Cust Sample No:POSF 7433 Date Reported:05/04/11 2006 hrs* Protocol:FU-AVI-0133
JON: AFCO-001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

JP-8 sample from the filter evaluation testing being done at Facet. Test #4 sample (CI/LI only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	05/04/2011*

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30677001 Date Received:03/30/11 0829 hrs* Date Sampled: 03/16/2011**
Cust Sample No:POSF 7418 Date Reported:03/30/11 1638 hrs* Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: Facet Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST 4

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.002	
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.6	
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.01	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		150	
	10% Recovered (°C)		205	171	
	20% Recovered (°C)	Report Only		181	
	50% Recovered (°C)	Report Only		210	
	90% Recovered (°C)	Report Only		253	
	End Point (°C)		300	268	
	T50 - T10 (°C)	15		39	
	T90 - T10 (°C)	40		82	
	Residue (% vol)		1.5	1.4	
	Loss (% vol)		1.5	0.6	
ASTM D 93 - 10a	Flash Point (°C)	38		48	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-54	
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	5.1	
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		10.7	
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.4	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.6	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		30.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 7224 - 08	WSIM	Report Only		95	
ASTM D 2624 - 09	Conductivity				
	Conductivity (pS/m)	Report Only		0	
	Test Temperature (°F)			70	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.57	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		11	

Dispositions:
For information purposes only.

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30677001 | Date Received:03/30/11 0829 hrs* | Date Sampled: 03/16/2011**
Cust Sample No:POSF 7418 | Date Reported:03/30/11 1638 hrs* | Protocol:FU-AVI-0129
JON: AFCO-001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet (Greensboro NC). Test #4 sample (CI/LI only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	Date
Miguel Acevedo, Chief \\SIGNED\\	03/30/2011*

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31221001 Date Received:04/28/11 0941 hrs* Date Sampled: 04/19/2011**
Cust Sample No:POSF 7434 Date Reported:05/06/11 1416 hrs* Protocol:FU-AVI-0133
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:JP-8

Source: FACET Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST #5 FUEL B4
START

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.002
ASTM D 1319 - 10	Aromatics (% vol)		25.0	16.9
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		158
	10% Recovered (°C)		205	177
	20% Recovered (°C)	Report Only		184
	50% Recovered (°C)	Report Only		201
	90% Recovered (°C)	Report Only		235
	End Point (°C)		300	258
	Residue (% vol)		1.5	1.3
	Loss (% vol)		1.5	0.5
ASTM D 93 - 10a	Flash Point (°C)	38		50
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.797
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53
ASTM D 445 - 10	Viscosity @ -20°C (mm²/s)		8.0	4.2
ASTM D 445 - 10	Viscosity @ -40°C (mm²/s)	Report Only		10.3
ASTM D 445 - 10	Viscosity @ 40°C (mm²/s)	Report Only		1.3
ASTM D 4809 09a	Net Heat of Combustion (MJ/kg)	42 8		43 2
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.0
ASTM D 1322 - 08	Smoke Point (mm)	25.0		25.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.13
ASTM D 7224 - 08	WSIM	Report Only		58
ASTM D 2624 - 09	Conductivity (pS/m)	Report Only		1017
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.62
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		24

Dispositions:
For information purposes only.
JP-8 sample from the filter evaluation testing being done at Facet. Test #5 sample (SDA and FSII only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31221001	Date Received:04/28/11 0941 hrs*	Date Sampled: 04/19/2011**
Cust Sample No:POSF 7434	Date Reported:05/06/11 1416 hrs*	Protocol:FU-AVI-0133
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	05/06/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30678001 Date Received:03/30/11 0831 hrs* Date Sampled: 03/17/2011**
Cust Sample No:POSF 7419 Date Reported:04/01/11 0851 hrs* Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: Facet Qty Submitted: 1 gal Qty Rep: 13,000 g
Batch/Lot/Origin TEST 5

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.001
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.2
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.01
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		151
	10% Recovered (°C)		205	172
	20% Recovered (°C)	Report Only		182
	50% Recovered (°C)	Report Only		210
	90% Recovered (°C)	Report Only		253
	End Point (°C)		300	268
	T50 - T10 (°C)	15		38
	T90 - T10 (°C)	40		81
	Residue (% vol)		1.5	1.3
	Loss (% vol)		1.5	0.5
ASTM D 93 - 10a	Flash Point (°C)	38		48
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.8
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		10.4
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.5
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6
ASTM D 1322 - 08	Smoke Point (mm)	25.0		26.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.13
ASTM D 7224 - 08	WSIM	Report Only		75
ASTM D 2624 - 09	Conductivity			
	Conductivity (pS/m)	Report Only		834
	Test Temperature (°F)			70
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.69
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		18

Dispositions:
For information purposes only.

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
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Lab Report No:2011LA30678001	Date Received:03/30/11 0831 hrs*	Date Sampled: 03/17/2011**
Cust Sample No:POSF 7419	Date Reported:04/01/11 0851 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet. Test #5 sample (SDA and FSII only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	04/01/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31223001 Date Received:04/28/11 0944 hrs* Date Sampled: 04/21/2011**
Cust Sample No:POSF 7435 Date Reported:05/04/11 2008 hrs* Protocol:FU-AVI-0133
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:JP-8

Source: FACET Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST #6 FUEL B4
START

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004	
ASTM D 1319 - 10	Aromatics (% vol)		25.0	17.1	
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		159	
	10% Recovered (°C)		205	177	
	20% Recovered (°C)	Report Only		184	
	50% Recovered (°C)	Report Only		201	
	90% Recovered (°C)	Report Only		234	
	End Point (°C)		300	259	
	Residue (% vol)		1.5	1.0	
	Loss (% vol)		1.5	0.4	
ASTM D 93 - 10a	Flash Point (°C)	38		50	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.797	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-52	
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.2	
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		8.4	
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		42.9	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		13.9	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		25.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 7224 - 08	WSIM	Report Only		78	
ASTM D 2624 - 09	Conductivity (pS/m)	Report Only		940	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.59	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		26	

Dispositions:

Coordinated with Emilio Alfaro (PTPT), phone: DSN 785-8050, COM 937-255-8050.
For information purposes only.

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** Date as provided by customer

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31223001	Date Received:04/28/11 0944 hrs*	Date Sampled: 04/21/2011**
Cust Sample No:POSF 7435	Date Reported:05/04/11 2008 hrs*	Protocol:FU-AVI-0133
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

JP-8 sample from the filter evaluation testing being done at Facet. Test #6 sample (SDA and CI/LI only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	05/04/2011*

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30774001 | Date Received:04/04/11 1231 hrs* | Date Sampled: 03/21/2011**
Cust Sample No:POSF 7421 | Date Reported:04/07/11 1344 hrs* | Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: FACET | Qty Submitted: 1 gal | Qty Rep: 13,000 gal
Batch/Lot/Origin TEST 6

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133G	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004	
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.4	
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02	
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 10a	Distillation				
	Initial Boiling Point (°C)	Report Only		149	
	10% Recovered (°C)		205	172	
	20% Recovered (°C)	Report Only		182	
	50% Recovered (°C)	Report Only		210	
	90% Recovered (°C)	Report Only		254	
	End Point (°C)		300	269	
	T50 - T10 (°C)	15		38	
	T90 - T10 (°C)	40		82	
	Residue (% vol)		1.5	1.4	
	Loss (% vol)		1.5	0.4	
ASTM D 93 - 10a	Flash Point (°C)	38		48	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53	
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.8	
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		10.2	
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.4	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.5	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		33.0	
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 3241 - 09e1	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.00	X
ASTM D 7224 - 08	WSIM	Report Only		87	
ASTM D 2624 - 09	Conductivity				
	Conductivity (pS/m)	Report Only		705	
	Test Temperature (°F)			71	
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.53	
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		22	

Dispositions:
For information purposes only.

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** Date as provided by customer

AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30774001	Date Received:04/04/11 1231 hrs*	Date Sampled: 03/21/2011**
Cust Sample No:POSF 7421	Date Reported:04/07/11 1344 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet. Test #6 sample (SDA and CI/LI only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	04/07/2011*

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afpet.afth@wpafb.af.mil, afpet.aftt@wpafb.af.mil, beatriz.rodriguez@wpafb.af.mil, benet.curtis@wpafb.af.mil, david.benson2@wpafb.af.mil, emilio.alfaro@wpafb.af.mil, gordon.walker@wpafb.af.mil, james.edwards@wpafb.af.mil, jeffrey.braun@wpafb.af.mil, jennifer.engelman@wpafb.af.mil, john.datko@wpafb.af.mil, michael.cole@wpafb.af.mil, miguel.acevedo@wpafb.af.mil, rhonda.cook@wpafb.af.mil, teresa.boyd@wpafb.af.mil, thomas.harmon@wpafb.af.mil, timothy.mudry@wpafb.af.mil, virgil.regoli@wpafb.af.mil

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31368001 | Date Received:05/06/11 0706 hrs* | Date Sampled: 04/25/2011**
Cust Sample No:POSF 7437 | Date Reported:05/11/11 0923 hrs* | Protocol:FU-AVI-0133
JON: AFCO-001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:JP-8

Source: FACET | Qty Submitted: 1 gal | Qty Rep: 13,000 gal
Batch/Lot/Origin: TEST #7

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.002
ASTM D 1319 - 10	Aromatics (% vol)		25.0	17.0
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.03
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		159
	10% Recovered (°C)		205	176
	20% Recovered (°C)	Report Only		183
	50% Recovered (°C)	Report Only		201
	90% Recovered (°C)	Report Only		235
	End Point (°C)		300	257
	Residue (% vol)		1.5	1.1
	Loss (% vol)		1.5	0.9
ASTM D 93 - 10a	Flash Point (°C)	38		50
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.797
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.1
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		8.4
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.80		43.25
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		13.9
ASTM D 1322 - 08	Smoke Point (mm)	25.0		26.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.13
ASTM D 7224 - 08	WSIM	Report Only		91
ASTM D 2624 - 09	Conductivity (pS/m)	Report Only		0
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.52
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		30

Dispositions:
For information purposes only.
JP-8 sample from the filter evaluation testing being done at Facet. Test #7 sample (FSII and CI/LI only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

* Date reflects Eastern Standard Time(EST) | Report Generated: 05/11/11 09:23*
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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31368001	Date Received:05/06/11 0706 hrs*	Date Sampled: 04/25/2011**
Cust Sample No:POSF 7437	Date Reported:05/11/11 0923 hrs*	Protocol:FU-AVI-0133
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	05/11/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30775001 Date Received:04/04/11 1234 hrs* Date Sampled: 03/22/2011**
Cust Sample No:POSF 7422 Date Reported:04/07/11 1347 hrs* Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: FACET Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST 7

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.3
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		151
	10% Recovered (°C)		205	171
	20% Recovered (°C)	Report Only		181
	50% Recovered (°C)	Report Only		210
	90% Recovered (°C)	Report Only		253
	End Point (°C)		300	268
	T50 - T10 (°C)	15		39
	T90 - T10 (°C)	40		82
	Residue (% vol)		1.5	1.4
	Loss (% vol)		1.5	0.5
ASTM D 93 - 10a	Flash Point (°C)	38		49
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53
ASTM D 445 - 10	Viscosity @ -20°C (mm²/s)		8.0	4.9
ASTM D 445 - 10	Viscosity @ -40°C (mm²/s)	Report Only		10.2
ASTM D 445 - 10	Viscosity @ 40°C (mm²/s)	Report Only		1.4
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.6
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6
ASTM D 1322 - 08	Smoke Point (mm)	25.0		34.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.14
ASTM D 7224 - 08	WSIM	Report Only		91
ASTM D 2624 - 09	Conductivity			
	Conductivity (pS/m)	Report Only		3
	Test Temperature (°F)			71
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.52
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		29

Dispositions:
For information purposes only.

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30775001 Date Received:04/04/11 1234 hrs* Date Sampled: 03/22/2011**
Cust Sample No:POSF 7422 Date Reported:04/07/11 1347 hrs* Protocol:FU-AVI-0129
JON: AFCO-001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet. Test #7 sample (FSII and CI/LI only). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	04/07/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30776001 | Date Received:04/04/11 1236 hrs* | Date Sampled: 03/24/2011**
Cust Sample No:POSF 7423 | Date Reported:04/07/11 1348 hrs* | Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: FACET | Qty Submitted: 1 gal | Qty Rep: 13,000 gal
Batch/Lot/Origin TEST 8

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.2
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		151
	10% Recovered (°C)		205	172
	20% Recovered (°C)	Report Only		182
	50% Recovered (°C)	Report Only		210
	90% Recovered (°C)	Report Only		253
	End Point (°C)		300	269
	T50 - T10 (°C)	15		38
	T90 - T10 (°C)	40		81
	Residue (% vol)		1.5	1.4
	Loss (% vol)		1.5	0.6
ASTM D 93 - 10a	Flash Point (°C)	38		49
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	5.1
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		10.3
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.4
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.5
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6
ASTM D 1322 - 08	Smoke Point (mm)	25.0		34.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.14
ASTM D 7224 - 08	WSIM	Report Only		69
ASTM D 2624 - 09	Conductivity			
	Conductivity (pS/m)	Report Only		881
	Test Temperature (°F)			71
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.51
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		31

Dispositions:
For information purposes only.

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** Date as provided by customer

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30776001	Date Received:04/04/11 1236 hrs*	Date Sampled: 03/24/2011**
Cust Sample No:POSF 7423	Date Reported:04/07/11 1348 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet. Test #8 sample (SDA, CI/LI and FSII). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	04/07/2011*

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30777001	Date Received:04/04/11 1238 hrs*	Date Sampled: 03/29/2011**
Cust Sample No:POSF 7424	Date Reported:04/07/11 1349 hrs*	Protocol:FU-AVI-0129
JON: AFCO 001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: FACET	Qty Submitted: 1 gal	Qty Rep: 13,000 gal
Batch/Lot/Origin TEST 9		

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.5
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.001
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		146
	10% Recovered (°C)		205	172
	20% Recovered (°C)	Report Only		182
	50% Recovered (°C)	Report Only		210
	90% Recovered (°C)	Report Only		254
	End Point (°C)		300	269
	T50 - T10 (°C)	15		38
	T90 - T10 (°C)	40		82
	Residue (% vol)		1.5	1.3
	Loss (% vol)		1.5	0.7
ASTM D 93 - 10a	Flash Point (°C)	38		49
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.8
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		10.4
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.4
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.5
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6
ASTM D 1322 - 08	Smoke Point (mm)	25.0		34.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.14
ASTM D 7224 - 08	WSIM	Report Only		66
ASTM D 2624 - 09	Conductivity			
	Conductivity (pS/m)	Report Only		865
	Test Temperature (°F)			71
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.52
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		20

Dispositions:
For information purposes only.

* Date reflects Eastern Standard Time(EST) | Report Generated: 04/7/11 13:49*
** Date as provided by customer

AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30777001	Date Received:04/04/11 1238 hrs*	Date Sampled: 03/29/2011**
Cust Sample No:POSF 7424	Date Reported:04/07/11 1349 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet. Test #9 sample (SDA, CI/LI and FSII; with 50/50 blend of Arizona A1 and A3 test dust). Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	04/07/2011*

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31364001 Date Received:05/05/11 1531 hrs* Date Sampled: 05/03/2011**
Cust Sample No:POSF 7436 Date Reported:05/06/11 1508 hrs* Protocol:FU-AVI-0133
JON: AFCO-001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:JP-8

Source: FACET Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin: TEST #10

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.003
ASTM D 1319 - 10	Aromatics (% vol)		25.0	16.8
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		166
	10% Recovered (°C)		205	178
	20% Recovered (°C)	Report Only		185
	50% Recovered (°C)	Report Only		201
	90% Recovered (°C)	Report Only		234
	End Point (°C)		300	258
	Residue (% vol)		1.5	1.0
	Loss (% vol)		1.5	0.5
ASTM D 93 - 10a	Flash Point (°C)	38		51
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.797
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-52
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.2
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		8.4
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.2
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		13.9
ASTM D 1322 - 08	Smoke Point (mm)	25.0		25.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.13
ASTM D 7224 - 08	WSIM	Report Only		54
ASTM D 2624 - 09	Conductivity (pS/m)	Report Only		950
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.52
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		31

Dispositions:
For information purposes only.
JP-8 sample from the filter evaluation testing being done at Facet. Test #10 sample (SDA, CI/LI and FSII). It was run for and funded by Pond & Company for comparison against SwRI testing. Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA31364001	Date Received:05/05/11 1531 hrs*	Date Sampled: 05/03/2011**
Cust Sample No:POSF 7436	Date Reported:05/06/11 1508 hrs*	Protocol:FU-AVI-0133
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	05/06/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
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Lab Report No:2011LA30836001 Date Received:04/07/11 0732 hrs* Date Sampled: 03/31/2011**
Cust Sample No:POSF 7425 Date Reported:04/11/11 1109 hrs* Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: FACET Qty Submitted: 1 gal Qty Rep: 13,000 gal
Batch/Lot/Origin TEST 10

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.6
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.001
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		148
	10% Recovered (°C)		205	171
	20% Recovered (°C)	Report Only		182
	50% Recovered (°C)	Report Only		210
	90% Recovered (°C)	Report Only		253
	End Point (°C)		300	268
	T50 - T10 (°C)	15		39
	T90 - T10 (°C)	40		82
	Residue (% vol)		1.5	1.5
	Loss (% vol)		1.5	0.4
ASTM D 93 - 10a	Flash Point (°C)	38		48
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.9
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		10.8
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.3
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.5
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6
ASTM D 1322 - 08	Smoke Point (mm)	25.0		35.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.14
ASTM D 7224 - 08	WSIM	Report Only		60
ASTM D 2624 - 09	Conductivity			
	Conductivity (pS/m)	Report Only		745
	Test Temperature (°F)			70
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.52
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		32

Dispositions:
For information purposes only.

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
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Lab Report No:2011LA30836001	Date Received:04/07/11 0732 hrs*	Date Sampled: 03/31/2011**
Cust Sample No:POSF 7425	Date Reported:04/11/11 1109 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet. Test #10 sample (SDA, CI/LI and FSII). It was run for and funded by Pond & Company for comparison against SwRI testing. Volume represented: approx 13,000 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	04/11/2011*

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AFPET LABORATORY REPORT

HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No:2011LA30837001 Date Received:04/07/11 0738 hrs* Date Sampled: 04/04/2011**
Cust Sample No:POSF 7426 Date Reported:04/11/11 1545 hrs* Protocol:FU-AVI-0129
JON: AFCO 001

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Reason for Submission: AFCO Demo/Test
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133G Grade:HRJ (50/50)

Source: FACET Qty Submitted: 1 gal Qty Rep: 12,568 gal
Batch/Lot/Origin OFF LOADED FUEL W/ ADD.

Method	Test	Min	Max	Result
MIL-DTL-83133G	Workmanship			Pass
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.004
ASTM D 1319 - 10	Aromatics (% vol)	8.0	25.0	8.4
ASTM D 4294 - 10	Sulfur (% mass)		0.30	0.02
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000
ASTM D 86 - 10a	Distillation			
	Initial Boiling Point (°C)	Report Only		148
	10% Recovered (°C)		205	170
	20% Recovered (°C)	Report Only		181
	50% Recovered (°C)	Report Only		209
	90% Recovered (°C)	Report Only		253
	End Point (°C)		300	268
	T50 - T10 (°C)	15		39
	T90 - T10 (°C)	40		83
	Residue (% vol)		1.5	1.5
	Loss (% vol)		1.5	0.4
ASTM D 93 - 10a	Flash Point (°C)	38		48
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.775	0.840	0.781
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	-53
ASTM D 445 - 10	Viscosity @ -20°C (mm^2/s)		8.0	4.7
ASTM D 445 - 10	Viscosity @ -40°C (mm^2/s)	Report Only		11.1
ASTM D 445 - 10	Viscosity @ 40°C (mm^2/s)	Report Only		1.4
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		43.5
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		14.6
ASTM D 1322 - 08	Smoke Point (mm)	25.0		35.0
ASTM D 130 - 10	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a
ASTM D 3241 - 09e1	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)		25	0
	Tube Deposit Rating, Visual	<3 (Max)		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0
ASTM D 5006 - 10e1	FSII (% vol)	0.10	0.15	0.12
ASTM D 7224 - 08	WSIM	Report Only		80
ASTM D 2624 - 09	Conductivity			
	Conductivity (pS/m)	Report Only		420
	Test Temperature (°F)			70
ASTM D 5001 - 10	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.53
ASTM D 6304-07	Water, Coulometric Karl Fischer Titration (mg/kg)	Report Only		31

Dispositions:

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
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Lab Report No:2011LA30837001	Date Received:04/07/11 0738 hrs*	Date Sampled: 04/04/2011**
Cust Sample No:POSF 7426	Date Reported:04/11/11 1545 hrs*	Protocol:FU-AVI-0129
JON: AFCO-001		

Sample Submitter:
HQ AFPET/PTOT
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632
For information purposes only.
50/50 tallow HRJ/JP-8 sample from the filter evaluation testing being done at Facet. Fuel blend was clay treated after test #10, re-additized with SDA, CI/LI and FSII at JP-8 specification requirements, and shipped to Honeywell. Volume represented: 12,568 gallons. This testing is in support of the USAF Alternative Fuel Certification Program.

Approved By	**Date**
Miguel Acevedo, Chief \\SIGNED\\	04/11/2011*

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